~~CR-109890~~

Syracuse/NASA Program

Report No. 1

Statistical APL Programs

by

G. Harry McLaughlin
Communications Research Center
School of Journalism
Syracuse University

(NASA-CR-109890) STATISTICAL APL PROGRAMS (Syracuse Univ.) 58 p

N90-70647

Unclas
00/61 0278572

June, 1970

NGL 33-022-090

This report is a by-product of my Syracuse/NASA Program project "Exposition and Real-Time Decision-Making".

While making statistical studies of expository style I found a need to supplement the generally excellent set of functions in STATPAK 2 by K.W. Smillie (Department of Computing Science, University of Alberta, Edmonton, Alberta). Generally, STATPAK 2 makes sophisticated use of APL's array orientation. Unfortunately, the 32K-bit limitation on work spaces available in Syracuse University's implementation of APL often makes it impossible to use one of these functions with an output vector of length N, where N is greater than say, 40, if during the execution of the function on NxN matrix is produced, as this leads to a WS FULL error. There is also a need for more functions to test goodness of fit, to perform non-parametric tests, and to output frequency tables. I hope that the functions described in the following pages will help meet these needs.

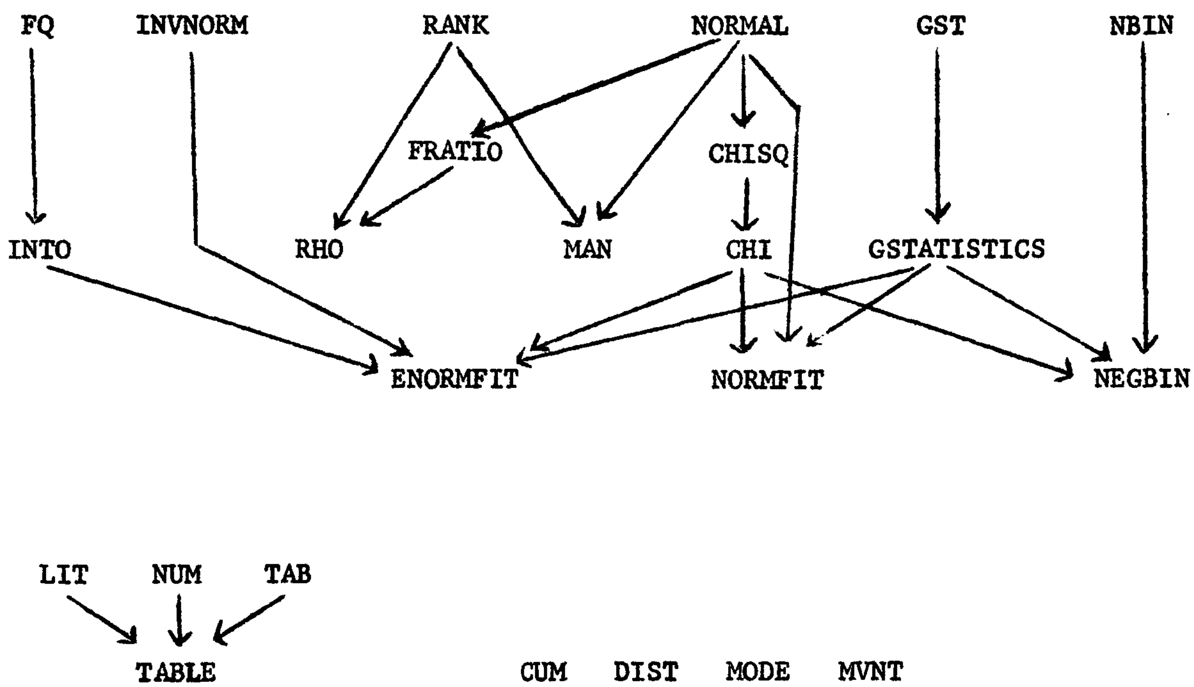
The descriptions are arranged alphabetically. They are set out in the standard form for Syracuse University APL documentation. All functions are given a C confidence rating although, with the exception of ENORMFIT, they have all been tested fairly extensively. The C rating invites users to send me their comments and modifications. After the documentation for each function, it is displayed and examples are given of its use.

No execution times are given because the TIME function works erratically with the Syracuse University Operating System. However, the documentation includes a warning if a function is iterative and therefore tends to consume a lot of CPU time.

The group of functions TABLE, LIT, NUM, and TAB placed separately at the end of this report may be of interest to educators as the first three functions named are fully conversational.

All functions can be used independently, though many serve as subfunctions. In the graph below an arrow connects each subfunction to the function by which it is called.

Relationships of functions



CHIHOW

X CHI OB

05/04/70

CONFIDENCE CODE: C

1-ORIGIN INDEXING

DR.G.H.MCLAUGHLIN

NEWHOUSE COMMUNICATIONS CENTER, SYR. UNIV. X2747

FUNCTION DESCRIPTION

CHI CALCULATES AND DISPLAYS CHI-SQUARE, ITS DEGREES OF FREEDOM, AND ITS PROBABILITY. THE LAST FIGURE IS GENERALLY ACCURATE TO AT LEAST THREE DECIMAL PLACES.

IF REQUIRED, CHI DISPLAYS EXPECTED VALUES CALCULATED FROM OBSERVED VALUES OF A SINGLE SAMPLE OR ANY SIZED CONTINGENCY TABLE. CHI AUTOMATICALLY CONFLATES CLASSES, IF NECESSARY, TO ELIMINATE EXPECTED VALUES OF LESS THAN 1 , AND TO REDUCE TO 20 PER CENT OR LESS THE PROPORTION OF EXPECTED VALUES LESS THAN 5 .

YATES' CORRECTION FOR CONTINUITY IS AUTOMATICALLY APPLIED WHEN THERE IS A SINGLE DEGREE OF FREEDOM.

FUNCTION SYNTAX: X CHI OB

LEFT ARGUMENT - X:

MUST BE AN ARRAY OF EXPECTED VALUES,
OR 0 IF EXPECTED VALUES ARE TO BE CALCULATED BY THE FUNCTION ITSELF.

RIGHT ARGUMENT - OB:

MUST BE A MATRIX OR VECTOR OF OBSERVED VALUES.

GLOBAL VARIABLES REQUIRED:

GLOBAL VARIABLE	DESCRIPTION
ESTIMATES	DETERMINES THE DEGREES OF FREEDOM OF CHI.

AFTER COPYING CHI INTO A WORKSPACE FOR THE FIRST TIME, SET
ESTIMATES←0,0
THIS ENSURES THAT THE PROBABILITY OF A CALCULATED CHI-SQUARE WILL BE DETERMINED FOR (R-1)×(K-1) DEGREES OF FREEDOM.

IF $\underline{N}$ *PARAMETERS HAVE BEEN ESTIMATED FROM OBSERVED VALUES IN ORDER TO PROVIDE A LEFT ARGUMENT OF EXPECTED VALUES, THE DEGREES OF FREEDOM MUST BE REDUCED BY* $\underline{N}$ *. TO DO SO, SET*

```
ESTIMATES←3N-1
```

AFTER EXECUTION ESTIMATES WILL AUTOMATICALLY BE ZEROED. HOWEVER, IF CHI IS TO BE USED $\underline{R}$ *TIMES WITH ESTIMATES EQUAL TO* $\underline{N}$ *, THE CHORE OF REPEATED RESETTINGS CAN BE AVOIDED BY SETTING*

```
ESTIMATES←(2+R)ρN-1
```

THE VALUE WILL NOT BECOME ZERO UNTIL AFTER $\underline{R}$ *EXECUTIONS OF CHI OR UNTIL*

```
ESTIMATES←0,0
```

IS ENTERED.

SUBFUNCTIONS REQUIRED:

SUBFUNCTION	*DESCRIPTION*
CHISQ	*COMPUTES THE PROBABILITY OF GIVEN CHI-SQUARED AND D.F. VALUES*
NORMAL	*CALLED BY CHISQ TO CALCULATE THE PROBABILITY OF A NORMAL DEVIATE, USING A SIXTH-ORDER POLYNOMIAL APPROXIMATION.*

FUNCTION OUTPUT:

```
THERE IS NO RESULTANT.
IF  OB  IS A VECTOR AND  X  IS  0  THE FOLLOWING
PRINTOUT APPEARS:
EACH EXPECTED VALUE IS (VALUE)
IF  OB  IS A MATRIX AND  X  IS  0  THE FOLLOWING
PRINTOUT APPEARS:
OBSERVED VALUES
(TABLE)
EXPECTED VALUES
(TABLE)
IN ALL CASES, THE FOLLOWING IS PRINTED OUT:
CHI-SQUARED        (CALCULATED VALUE)
DEGREES OF FREEDOM (VALUE - INDICATING THE DEGREE
                    OF CLASS CONFLATION, IF ANY)
PROBABILITY        (VALUE)
```

```
      ∇CHI[⎕]∇
    ∇ X CHI OB;D;T;Q;K
[1]    ESTIMATES[1 2]← 0 0
[2]    →((T×K=1),((~T)×K=1),(T×K=2),(~T←0=+/,X)×(2=K←⍴,D←⍴OB))/EQ,VE,
       MA,AM
[3]   EQ:'EACH EXPECTED VALUE IS ';X←(+/OB)÷×/D
[4]   VE:OB←(1,D)⍴OB
[5]    →CH,,X←(1,D)⍴X
[6]   MA:'OBSERVED VALUES';OB
[7]    'EXPECTED VALUES';X←(÷+/T)×(+/OB)∘.×T←+⌿OB
[8]   AM:→((+/×⌿K)≥+/×/K←X≥5)/CH
[9]    OB←⍉OB
[10]   X←⍉X
[11]  CH:T←K←0×D←(⍴X)[2]
[12]   →(∨/∨/X<1)+1+⌶26
[13]  LA:→((+/+/5<X)≥⌊(⍴,X)÷5)/CC
[14]   J←((∨⌿X<T←T+1)/⍳D),D
[15]  TE:→(D=K←(J←,(K<J)/J)[1])/OP
[16]  TT:OB[;K]←OB[;K←K+1]+OB[;K]
[17]   X[;K]←X[;K]+X[;K-1]
[18]   OB[;K-1]←X[;K-1]←○2
[19]  OP:→((Q×K=D),Q,(K≠D)×~Q←×/T≤X[;K])/LA,TE,TT
[20]   X[;D]←X[;D]+X[;Q←⌈/Q×X[1;Q←⍳D-1]≠○2]
[21]   OB[;D]←OB[;D]+OB[;Q]
[22]   OB[;Q]←X[;Q]←○2
[23]   →LA
[24]  CC:X←(Q←×⌿X≠○2)/X
[25]   OB←Q/OB
[26]   Q←1=D←(D[2]-1≠D[2])×D[1]-1≠(D←⍴X)[1]
[27]   'CHI-SQUARED           ';T←+/+/(((|OB-X)-Q×
       0.5)*2)÷X
[28]   'DEGREES OF FREEDOM ';D-ESTIMATES[⍴ESTIMATES]
[29]   'PROBABILITY           ';D CHISQ T
[30]   ESTIMATES←(¯2<⍴ESTIMATES)↓ESTIMATES
    ∇
      WINS
29  19  18  25  17  10  15  11
      0 CHI WINS
EACH EXPECTED VALUE IS 18
CHI-SQUARED          16.33333333
DEGREES OF FREEDOM 7
PROBABILITY          0.02223970421

      0 CHI HEIGHT
OBSERVED VALUES
  12  32
  22  14
   9   6
EXPECTED VALUES
    19.91578947      24.08421053
    16.29473684      19.70526316
     6.789473684      8.210526316
CHI-SQUARED          10.71219801
DEGREES OF FREEDOM 2
PROBABILITY          0.004719280137
```

X1

12	14	0
32	0	0
1	9	1
22	6	0

X2

10	15	5
20	10	6
5	5	5
5	6	5

X1 CHI X2

CHI-SQUARED	7.712787213
DEGREES OF FREEDOM	3
PROBABILITY	0.05233561753

PROB←DF CHISQ X
05/01/70
CONFIDENCE CODE: C
1-*ORIGIN INDEXING*
DR.G.H.MCLAUGHLIN
*NEWHOUSE COMMUNICATIONS CENTER, SYR. UNIV. X*2747

FUNCTION DESCRIPTION

CHISQ OUTPUTS THE PROBABILITY OF A CALCULATED CHI-SQUARED VALUE. FOR EVEN D.F. LESS THAN 40 *AND X LESS THAN* 150, *ITS ACCURACY IS THAT OF THE COMPUTER. OTHERWISE THE RESULT IS GENERALLY CORRECT TO AT LEAST THREE DECIMAL PLACES, DEPENDING MAINLY UPON THE ACCURACY OF THE SUBFUNCTION NORMAL. CHISQ OPERATES VERY RAPIDLY, BEING NON-ITERATIVE ALTHOUGH MATHEMATICALLY EQUIVALENT TO THE HIGHLY ITERATIVE ALGORITHM* 299 *IN COLLECTED ALGORITHMS FROM CACM*

FUNCTION SYNTAX: *PROB←DF CHISQ X*

RESULTANT - PROB:

IS A (SCALAR) PROBABILITY VALUE

LEFT ARGUMENT - DF:

MUST BE A POSITIVE INTEGER REPRESENTING DEGREES OF FREEDOM

RIGHT ARGUMENT - X:

MUST BE A POSITIVE NUMBER REPRESENTING A CALCULATED CHI-SQUARED VALUE

SUBFUNCTIONS REQUIRED:

SUBFUNCTION	DESCRIPTION
NORMAL	*CALCULATES THE PROBABILITY OF A NORMAL DEVIATE, USING A SIXTH-ORDER POLYNOMIAL APPROXIMATION*

FUNCTION OUTPUT:

RESULTANT PROB ONLY

```
      ∇CHISQ[⎕]∇
    ∇ PROB←DF CHISQ X;A;B;C;EVEN;ODD
[1]   →(DF=2,PROB←EVEN←*-A←X×0.5)/0
[2]   →(((~B)∧~C),((~B)∧C←(DF←⌊0.5×DF)≠0.5×DF),B←(DF>40)∨X>150)/
      3 4 7
[3]   →0,PROB←EVEN×1++/(A*⍳DF)÷!⍳DF←DF-1
[4]   →(0=DF×⍴⍴⍴PROB←ODD←2×NORMAL-X*0.5)/0
[5]   B←(÷(!DF)×2*DF←0,⍳DF-1)×((2×DF)⍴ 1 0)/!⍳2×DF
[6]   →0,PROB←ODD+EVEN×+/(X*1+DF)÷B×(A×○1)*0.5
[7]   PROB←(NORMAL-((2×X)*0.5)-((4×DF)-1+2×C)*
      0.5)
    ∇

      1 CHISQ 3.841
0.05001395343

      2 CHISQ 5.991
0.05001161503

      9 CHISQ 16.919
0.04999985002

      10 CHISQ 18.307
0.05000058909

      50 CHISQ 67.505
0.04750857725

      30 CHISQ 14.954
0.9899969894
```

R←P CUM X
04/30/70
CONFIDENCE CODE: C
1-*ORIGIN INDEXING*
DR.G.H.MCLAUGHLIN
NEWHOUSE COMMUNICATIONS CENTER, SYR. UNIV. X2747

FUNCTION DESCRIPTION

CUM CUMULATES A (FREQUENCY) VECTOR GIVEN AS RIGHT ARGUMENT

FUNCTION SYNTAX: *R←P CUM X*

RESULTANT - R:

IS A VECTOR OF CUMULATIVE FRQUENCIES, IF P = 0
OR A VECTOR OF CUMULATIVE PERCENTAGE FRQUENCIES, IF P = 1
OR A TWO-ROW MATRIX CONSISTING OF CUMULATIVE FREQUENCIES IN THE FIRST ROW, AND CUMULATIVE PERCENTAGE FREQUENCIES IN THE SECOND, IF P = 2

LEFT ARGUMENT - P:

MUST BE 0 *OR* 1 *OR* 2 (*SEE ABOVE*)

RIGHT ARGUMENT - X:

MUST BE A VECTOR OF FREQUENCIES TO BE CUMULATED LEFT TO RIGHT

FUNCTION OUTPUT:

RESULTANT R ONLY

```
      ∇CUM[⎕]∇
    ∇ R←P CUM X;K;D
[1]   D←ρX
[2]   R←,K←0
[3]  SE:→((D+1)>ρR←R,R[K]+X[K←K+1])/SE
[4]   R←1↓R
[5]   →(P=0)/0
[6]   K←R×100÷R[ρR]
[7]   →(P=2)/TW
[8]   →0,R←K
[9]  TW:R←(2,ρK)ρR,K
    ∇

      ⍉2 10ρ2 CUM ⍳10

  1                 1.818181818
  3                 5.454545455
  6                10.90909091
 10                18.18181818
 15                27.27272727
 21                38.18181818
 28                50.90909091
 36                65.45454545
 45                81.81818182
 55               100
```

DISTHOW

FD←MP DIST F
05/01/70
CONFIDENCE CODE: C
1-*ORIGIN INDEXING*
DR.G.H.MCLAUGHLIN
NEWHOUSE COMMUNICATIONS CENTER, SYR. UNIV. X2747

FUNCTION DESCRIPTION

DIST CONVERTS A VECTOR OF CLASS FREQUENCIES BACK INTO RAW SCORES, ASSUMING THAT THE VALUES OF EACH CLASS WERE ORIGINALLY CONCENTRATED AT THE MIDPOINT

FUNCTION SYNTAX: FD←MP DIST F

RESULTANT - FD:

IS A VECTOR IN WHICH EACH CLASS MIDPOINT IS REPEATED AS MANY TIMES AS INDICATED BY THE FREQUENCY OF ITS CLASS

LEFT ARGUMENT - MP:

MUST BE EITHER A VECTOR OF MIDPOINTS IN INCREASING ORDER OR A VECTOR OF TWO VALUES:
MP[1] LOWEST MIDPOINT
MP[2] CLASS WIDTH

RIGHT ARGUMENT - F:

MUST BE A VECTOR OF FREQUENCIES ORDERED BY INCREASING CLASS SIZE

FUNCTION OUTPUT:

RESULTANT FD ONLY

```
      ∇DIST[⎕]∇
    ∇ FD←MP DIST F;J
[1]   →(2<ρMP)/3
[2]   MP←MP[1]+MP[2]×0,ι(ρF)-1
[3]   FD←ι0×J←1
[4]   →(ιF[J]=0)/6
[5]   FD←FD,F[J]ρMP[J]
[6]   →((ρF)≥J←J+1)/4
    ∇
      (ι5) DIST 1,2,1,2,1
1  2  2  3  4  4  5

      (1,3) DIST 1,2,1,2,1
1  4  4  7  10  10  13
```

ENORMFITHOW

E←B ENORMFIT F

06/09/70

CONFIDENCE CODE: C

1-ORIGIN INDEXING

DR.G.H.MCLAUGHLIN

NEWHOUSE COMMUNICATIONS CENTER, SYR. UNIV. X2747

FUNCTION DESCRIPTION

ENORMFIT SERVES THE SAME PURPOSE AS NORMFIT, BUT USING CLASSES WITH EQUAL PROBABILITIES, AS RECOMMENDED IN THE ADVANCED THEORY OF STATISTICS (VOL.2, 2ND. EDITION, 1967) BY KENDAL AND STUART. THE MANN-WALD PROCEDURE IS USED TO DETERMINE THE NUMBER OF CLASSES REQUIRED. FOR A GIVEN FREQUENCY DISTRIBUTION, ENORMFIT OUTPUTS DESCRIPTIVE STATISTICS. IT THEN CALCULATES THE RESULTANT NORMAL DISTRIBUTION, THE MEAN AND VARIANCE OF WHICH ARE ESTIMATED FROM THE GIVEN DISTRIBUTION. THE OBSERVED DISTRIBUTION IS THEN TESTED FOR GOODNESS OF FIT TO THE NORMAL DISTRIBUTION BY THE CHI-SQUARED TEST. IF NECESSARY TO MEET THE REQUIREMENTS OF THE TEST, THE FREQUENCY CLASSES ARE CONFLATED TO GIVE A TOTAL OF N CLASSES. N-3 DEGREES OF FREEDOM ARE USED BECAUSE THE TWO PARAMETERS OF THE NORMAL DISTRIBUTION AND A SCALING FACTOR ARE ESTIMATED FROM THE OBSERVATIONS.

FUNCTION SYNTAX: E←B ENORMFIT F

RESULTANT - E:

IS A MATRIX OF 6 COLUMNS
[;1] LOWER CLASS BOUNDS
[;2] UPPER CLASS BOUNDS
[;3] CLASS MIDPOINTS
[;4] OBSERVED FREQUENCIES
[;5] EXPECTED FREQUENCIES (ALL IDENTICAL)
[;6] DIFFERENCES BETWEEN [;4] AND [;5]

LEFT ARGUMENT - B:

MUST BE EITHER A VECTOR OF LOWER CLASS BOUNDS IN INCREASING ORDER, FOLLOWED BY THE HIGHEST CLASS BOUND, OR A VECTOR OF CLASS MIDPOINTS IN INCREASING ORDER.

RIGHT ARGUMENT - F:

MUST BE A VECTOR OF FREQUENCIES, ONE FOR EACH CLASS DEFINED BY B .

GLOBAL VARIABLES REQUIRED:

GLOBAL VARIABLE	DESCRIPTION
ALPHA	IS THE REQUIRED SIGNIFICANCE LEVEL FOR THE MANN-WALD PROCEDURE. ALPHA IS AUTOMATICALLY SET TO 0.05 UNLESS A DIFFERENT VALUE A IS REQUIRED, IN WHICH CASE SET ALPHA←A A A BEFORE USING THE FUNCTION. AFTER COPYING ENORMFIT INTO A WORKSPACE FOR THE FIRST TIME SET ALPHA←0 0

SUBFUNCTIONS REQUIRED:

SUBFUNCTION	DESCRIPTION
INVNORM	CALCULATES NORMAL DEVIATES CORRESPONDING TO GIVEN PROBABILITIES USED IN THE MANN-WALD PROCEDURE AND TO DETERMINE THE RESULTANT CLASS BOUNDS
INTO	REASSIGNS THE FREQUENCIES GIVEN BY F TO CLASSES DETERMINED BY INVORM
FQ	CALLED BY INTO TO PRODUCE THE RESULTANT FREQUENCY TABLE
GST	CALLED BY GSTATISTICS TO CALCULATE DESCRIPTIVE STATISTICS FROM GROUPED DATA
GSTATISTICS	DISPLAYS DESCRIPTIVE STATISTICS
CHI	CALCULATES CHI-SQUARED, USING A GLOBAL VARIABLE ESTIMATES WHICH IS SET AUTOMATICALLY BY NORMFIT
CHISQ	CALLED BY CHI TO COMPUTE THE PROBABILITY OF GIVEN CHI-SQUARED AND D.F. VALUES
NORMAL	CALCULATES THE PROBABILITY OF A NORMAL DEVIATE, USING A SIXTH-ORDER POLYNOMIAL APPROXIMATION

FUNCTION OUTPUT:

IN ADDITION TO RETURNING THE RESULTANT, ENORMFIT PRINTS OUT THESE ITEMS, FULLY LABELLED:
MEAN, S.E., S.D. AND NUMBER OF VALUES OF F;
CALCULATED CHI-SQUARE, ITS DEGREE OF FREEDOM, AND ITS PROBABILITY, GENERALLY ACCURATE TO AT LEAST THREE FIGURES.

```
      ∇ENORMFIT[⎕]∇
    ∇ E←B ENORMFIT F;E;N;S;ESTIMATES
[1]   S←B GSTATISTICS F
[2]   ALPHA[1 2]← 0.05 0.05
[3]   N←INVNORM ALPHA[ρALPHA]
[4]   N←⌊4×((2×(¯1+ρF)*2)÷N*2)*0.2
[5]   N←S[1]+(S[2]*0.5)×N←INVNORM 0.0001,((ιN-1)÷N),0.9999
[6]   E←(B,F) INTO N
[7]   E←⍉(6,ρN)ρE[;1],E[;2],E[;3],E[;4],N,E[;4]-N←NρS[3]÷N←(ρE)[1]
[8]   ESTIMATES← 2 2 2
[9]   E[;5] CHI E[;4]
[10]  ALPHA←(-2<ρALPHA)↓ALPHA
    ∇

      TIME ENORMFIT ORD
MEAN                79.11
STANDARD ERROR      2.002114791
STANDARD DEVIATION  20.02114791
NUMBER OF VALUES    100
CHI-SQUARED         17.44
DEGREES OF FREEDOM  5
PROBABILITY         0.01476919238

   4.640860975   56.0683081    30.35458454   18   12.5    5.5
  56.0683081     65.60344758   60.83587784    0   12.5  ¯12.5
  65.60344758    72.73098119   69.16721439   13   12.5    0.5
  72.73098119    79.10201519   75.91649819   14   12.5    1.5
  79.10201519    85.48901881   82.295517     17   12.5    4.5
  85.48901881    92.61655242   89.05278561   12   12.5   ¯0.5
  92.61655242   102.1516919    97.38412216   15   12.5    2.5
 102.1516919    153.579139    127.8654155    11   12.5   ¯1.5
```

```
F←P  FQ  X
05/04/70
CONFIDENCE CODE:  C
1-ORIGIN INDEXING
DR.G.H.MCLAUGHLIN
NEWHOUSE COMMUNICATIONS CENTER, SYR. UNIV.  X2747
```

FUNCTION DESCRIPTION

FQ OUTPUTS A FREQUENCY TABLE IN THE FORM OF A FOUR-COLUMN MATRIX. IT TAKES AS ARGUMENTS A VECTOR OF RAW DATA OR OF FREQUENCIES AND ANOTHER VECTOR MORE OR LESS DEFINING THE RESULTANT CLASS BOUNDS. REQUIRED VALUES ARE CALCULATED AUTOMATICALLY BY FQ IF THEY ARE NOT SUPPLIED BY THE USER.

IT IS ASSUMED THROUGHOUT THAT A CLASS INCLUDES EVERY VALUE EQUAL TO OR GREATER THAN THE LOWER BOUND OF THAT CLASS BUT LESS THAN ITS UPPER BOUND.

FUNCTION SYNTAX: F←P FQ X

RESULTANT - F:

IS A MATRIX, THE COLUMNS OF WHICH CONTAIN THE FOLLOWING VALUES:
R[;1] LOWER BOUNDS
R[;2] UPPER BOUNDS
R[;3] MIDPOINTS
R[;4] FREQUENCIES

LEFT ARGUMENT - P:

MUST BE ONE OF THE FOLLOWING:
EITHER A VECTOR OF FOUR OR MORE LOWER CLASS BOUNDS IN INCREASING ORDER FOLLOWED BY THE GREATEST UPPER CLASS BOUND [NOTE: ρP MUST NOT EQUAL ρX OR (ρX)-1 IF X IS A VECTOR OF RAW SCORES]
OR, IF X IS A VECTOR OF FREQUENCIES, P MAY BE A VECTOR OF MORE THAN FOUR CLASS MIDPOINTS IN INCREASING ORDER [NOTE: UNLESS ALL CLASSES ARE OF EQUAL WIDTH, THE ORIGINAL BOUNDS WILL NOT BE RECOVERED IN THE RESULTANT TABLE]
OR, IF X IS A VECTOR OF FREQUENCIES AND ALL CLASSES ARE OF EQUAL WIDTH, P CAN BE A VECTOR OF TWO VALUES:
P[1] LEAST CLASS BOUND
P[2] CLASS WIDTH
OR, IF X IS A VECTOR OF RAW DATA, P MAY BE ONE OF THE FOLLOWING:
EITHER A VECTOR OF THREE VALUES:
P[1] LEAST CLASS BOUND
P[2] CLASS WIDTH
P[3] NUMBER OF CLASSES
OR, A VECTOR OF FOUR VALUES, ONE OR MORE OF WHICH IS 0 TO INDICATE THAT THE RELEVANT VALUE IS TO BE DECIDED BY THE FUNCTION ITSELF:
P[1] LEAST CLASS BOUND
P[2] CLASS WIDTH
P[3] NUMBER OF CLASSES*
P[4] GREATEST CLASS BOUND
*[NOTE: IF P[3] IS 1 , THEN EACH DIFFERENT VALUE OF X WILL NORMALLY BE ALLOCATED TO A SEPARATE CLASS AND ALL CLASSES WILL BE EQUAL WIDTH. HOWEVER, A 'WS FULL' ERROR MAY OCCUR IF THE SMALLEST DIFFERENCE BETWEEN TWO NON-IDENTICAL VALUES IN X IS SMALL RELATIVE TO THE RANGE OF X . IN THAT CASE TYPE → AND START AGAIN WITH A DIFFERENT P .]
OR, THE VECTOR 0,0,0,0[NOTE: THIS ALLOCATES EACH DIFFERENT VALUE OF X TO A SEPARATE CLASS. NO CLASS WILL BE EMPTY, BUT THE CLASSES WILL VARY IN WIDTH. THIS OPTION IS MUCH MORE ECONOMICAL OF WORKSPACE THAN THE OPTION DISCUSSED IN THE PREVIOUS NOTE.]

RIGHT ARGUMENT - X:

MUST BE EITHER A VECTOR OF RAW DATA, IN ANY ORDER, OR A VECTOR OF FREQUENCIES ORDERED BY INCREASING CLASS VALUE, EACH EMPTY CLASS BEING REPRESENTED BY 0 .

FUNCTION OUTPUT:

RESULTANT F ONLY

```
      ∇FQ[⎕]∇
    ∇ F←P FQ X;J;K;R;S;T;B
[1]   →⌈/0,(2×R=2),(3×(R>4)×R≠S),(6×R=S←⍴X),((9×(R=4))-4×0=+/
      2⍴1↓P),19×3=R←⍴T←P
[2]   P←P[1]+P[2]×0,⍳⍴X
[3]   →((S+1)≠⍴B←P)/20
[4]   →23,F←X
[5]   T←(T∊K)/T←⍳K[⍴K←P[⍋P←X]]
[6]   B←(¯1↓T)+((1↓T)-¯1↓T)÷2
[7]   B←(B[1]-T[1]),B,T[⍴T]+T[⍴T]-B[⍴B]
[8]   →((×/P=X),~×/P=F←X)/ 20 23
[9]   J←((~J∊0)/J←J[⍋J←(1↓X)-¯1↓X←X[⍋X]])[1]
[10]  T←X[1]-(B←⌈X[S]+J÷2)-X[S]
[11]  P[4]←(B×P[4]=0)+P[4]×P[4]≠0
[12]  →⌈/13,((P[1]=0)+14×P[2]=0),((P[1]=0)+16×P[3]=0),18×P[3]=1
[13]  →19,P[1]←P[4]-P[2]×P[3]
[14]  →19,P[2]←(P[4]-P[1])÷P[3]
[15]  →19,P[2]←(P[4]-T)÷P[3]
[16]  →19,P[3]←(P[4]-P[1])÷P[2]
[17]  →19,P[3]←(P[4]-T)÷P[2]
[18]  P←(T-J÷2),J,⌈(B-T)÷J
[19]  B←P[1]+P[2]×0,⍳P[3]
[20]  K←(⍴(X←X[⍋X],(K←J-J|S)⍴B[J]))÷J←⍴B+F←P←0
[21]  F←F+(1↓T)-¯1↓T←+/B∘.>J↑X←(J×P>0)↓X
[22]  →(K>P←P+1)/21
[23]  F←⍉(4,⍴K)⍴F←J,K,(J+((K←1↓B)-J←¯1↓B)÷2),F
    ∇


      TIME FQ ORD
```

24	48	36	5
48	60	54	13
60	72	66	13
72	78	75	14
78	84	81	17
84	90	87	12
90	102	96	15
102	114	108	7
114	138	126	4

```
      ⎕←RAND←5?10
8  1  3  2  10

      (0,0,0,0) FQ RAND

    0.5              1.5              1                1
    1.5              2.5              2                1
    2.5              5.5              4                1
    5.5              9                7.25             1
    9               11               10                1

      (0,0,1,0) FQ RAND

   ¯0.5              0.5              0                0
    0.5              1.5              1                1
    1.5              2.5              2                1
    2.5              3.5              3                1
    3.5              4.5              4                0
    4.5              5.5              5                0
    5.5              6.5              6                0
    6.5              75              7                0
    7.5              8.5              8                1
    8.5              9.5              9                0
    9.5             10.5             10                1

      (1,3,4) FQ RAND

     1                4                2.5              3
     4                7                5.5              0
     7               10                8.5              1
    10               13               11.5              1

      (¯3,1,7) FQ 2,¯1.3,2,¯3,2.7,0,3

   ¯3               ¯2               ¯2.5              1
   ¯2               ¯1               ¯1.5              1
   ¯1                0               ¯0.5              0
    0                1                0.5              1
    1                2                1.5              0
    2                3                2.5              3
    3                4                3.5              1
```

PROB←FRATIO F
05/01/70
CONFIDENCE CODE: C
1-ORIGIN INDEXING
DR.G.H.MCLAUGHLIN
NEWHOUSE COMMUNICATIONS CENTER, SYR. UNIV. X2747

FUNCTION DESCRIPTION

FRATIO CALCULATES THE PROBABILITY OF A GIVEN F RATIO. IF THE DEGREES OF FREEDOM OF THE NUMERATOR ARE 4 OR LESS, KELLEY'S CORRECTION IS AUTOMATICALLY APPLIED. A T-TEST STATISTIC T CAN BE EVALUATED BY SETTING:

F[1] 1
F[2] DEGREES OF FREEDOM
F[3] T*2

FUNCTION SYNTAX: PROB←FRATIO F

RESULTANT - PROB:

IS THE (SCALAR) PROBABILITY OF THE GIVEN F RATIO. PROB IS GENERALLY CORRECT TO THREE DECIMAL PLACES

RIGHT ARGUMENT - F:

MUST CONSIST OF THREE NUMBERS:
F[1] DEGREES OF FREEDOM OF THE DENOMINATOR OF THE F RATIO
F[2] DEGREES OF FREEDOM OF THE NUMERATOR
F[3] F RATIO EXPRESSED AS A DECIMAL

SUBFUNCTIONS REQUIRED:

SUBFUNCTION	DESCRIPTION
NORMAL	CALCULATES THE PROBABILITY OF A NORMAL DEVIATE, USING A SIXTH-ORDER POLYNOMIAL APPROXIMATION

FUNCTION OUTPUT:

RESULTANT PROB ONLY

```
      ∇FRATIO[⎕]∇
    ∇ PROB←FRATIO F;A;B;C
[1]   →(C←F[3]≥1)/3
[2]   F←F[2],F[1],÷F[3]
[3]   A←(((1-B)×F[3]*÷3)-1-A)÷(((F[3]*2÷3)×B←2÷9×F[2])+A←2÷9×F[1])*
      0.5
[4]   →(B≥4)/6
[5]   A←A×1+(0.08×A*4)÷F[2]*3
[6]   PROB←|C-(NORMAL A)
    ∇

      FRATIO 4,6,4.53
0.05026692796

      FRATIO 120,30,1.68
0.05068900147

      FRATIO 4,120,2.45
0.04920092341

      FRATIO 1,1,6.314*2
0.1036734913

      FRATIO 1,30,1.697*2
0.09636052952

      .5×FRATIO 1,20,2.528*2
0.009564749939
```

GSTATISTICSHOW
N←C GSTATISTICS F
05/01/70
CONFIDENCE CODE: C
1-*ORIGIN INDEXING*

DR.G.H.MCLAUGHLIN
NEWHOUSE COMMUNICATIONS CENTER, SYR. UNIV. X2747

__FUNCTION DESCRIPTION__

GSTATISTICS CALCULATES AND DISPLAYS DESCRIPTIVE STATISTICS FOR GROUPED DATA.

__FUNCTION SYNTAX__: N←C GSTATISTICS F

RESULTANT - N:

IS A VECTOR OF FOUR ITEMS:
N[1] *MEAN*
N[2] *VARIANCE*
N[3] *NUMBER OF VALUES (I.E. SUM OF F)*
N[4] *TOTAL OF VALUES (I.E. SUM OF F×MIDPOINTS)*

LEFT ARGUMENT - C:

MUST BE ONE OF THE FOLLOWING:
__EITHER__ A VECTOR OF CLASS MIDPOINTS IN INCREASING ORDER
__OR__ A VECTOR OF LOWER CLASS BOUNDS (IN INCREASING ORDER)
FOLLOWED BY THE HIGHEST CLASS BOUND
__OR__ 1 *(IF THE CLASS MIDPOINTS ARE* 1,2,...,ρ*F*)
__OR__ 0 *(IF THE CLASS MIDPOINTS ARE* 0,1,2,...,(ρ*F*)-1)

RIGHT ARGUMENT - F:

MUST BE A VECTOR OF FREQUENCIES FOR THE CLASSES DEFINED BY C . EACH EMPTY CLASS MUST BE REPRESENTED BY THE VALUE 0 .

SUBFUNCTIONS REQUIRED:

__SUBFUNCTION__	*__DESCRIPTION__*
GST	*CALCULATES THE RESULTANT OF GSTATISTICS*

FUNCTION OUTPUT:

IN ADDITION TO RETURNING THE RESULTANT N , GSTATISTICS ALSO PRINTS OUT FOUR STATISTICS LABELLED:
MEAN
STANDARD ERROR
STANDARD DEVIATION
NUMBER OF VALUES

```
        ∇GSTATISTICS[⎕]∇
      ∇ N←C GSTATISTICS F
  [1]   N←C GST F
  [2]   'MEAN                ';N[1]
  [3]   'STANDARD ERROR      ';(N[2]*0.5)÷N[3]*0.5
  [4]   'STANDARD DEVIATION ';N[2]*0.5
  [5]   'NUMBER OF VALUES    ';N[3]
      ∇

      NOS
1  1  0  1  6  6  6  8  5  5  2  3  2  1  1  2

       0 GSTATISTICS NOS
MEAN                7.38
STANDARD ERROR      0.4658895376
STANDARD DEVIATION 3.294336513
NUMBER OF VALUES    50
7.38  10.85265306  50  369

       (2×⍳⍴NOS) GSTATISTICS NOS
MEAN                16.76
STANDARD ERROR      0.9317790752
STANDARD DEVIATION 6.588673026
NUMBER OF VALUES    50
16.76  43.41061224  50  838

       ((2×⍳1+⍴NOS)-1) GSTATISTICS NOS
MEAN                16.76
STANDARD ERROR      0.9317790752
STANDARD DEVIATION 6.588673026
NUMBER OF VALUES    50
16.76  43.41061224  50  838

       NOS GSTATISTICS (⍴NOS)⍴1
MEAN                3.125
STANDARD ERROR      0.6182973934
STANDARD DEVIATION 2.473189574
NUMBER OF VALUES    16
3.125  6.116666667  16  50
```

GSTHOW
N←C GST F
05/01/70
CONFIDENCE CODE: C
1-ORIGIN INDEXING
DR.G.H.MCLAUGHLIN
NEWHOUSE COMMUNICATIONS CENTER, SYR. UNIV. X2747

FUNCTION DESCRIPTION

GST CALCULATES MEAN, VARIANCE, NUMBER OF VALUES AND THEIR SUMS FROM GROUPED DATA. IT IS ASSUMED THAT THE CLASS VALUES ARE CONCENTRATED AT THE MIDPOINTS, WHICH ARE DERIVED FROM THE LEFT ARGUMENT C . THE CORRESPONDING FREQUENCIES ARE GIVEN BY THE RIGHT ARGUMENT F .

FUNCTION SYNTAX: N←C GST F

RESULTANT - N:

IS A VECTOR OF FOUR ITEMS:
N[1] MEAN
N[2] VARIANCE
N[3] NUMBER OF VALUES (I.E. SUM OF F)
N[4] TOTAL OF VALUES (I.E. SUM OF F×MIDPOINTS)

LEFT ARGUMENT - C:

MUST BE ONE OF THE FOLLOWING:
EITHER A VECTOR OF CLASS MIDPOINTS IN INCREASING ORDER
OR A VECTOR OF LOWER CLASS BOUNDS IN INCREASING ORDER FOLLOWED BY THE HIGHEST CLASS BOUND
OR 1 (IF THE CLASS MIDPOINTS ARE 1,2,...,⍴F)
OR 0 (IF THE CLASS MIDPOINTS ARE 0,1,2,..,(⍴F)+1)

RIGHT ARGUMENT - F:

MUST BE A VECTOR OF FREQUENCIES FOR THE CLASSES DEFINED BY C . EACH EMPTY CLASS MUST BE REPRESENTED BY THE VALUE 0 .

FUNCTION OUTPUT:

RESULTANT N ONLY

```
      ∇GST[⎕]∇
    ∇ N←C GST F;V;M;T
[1]    →((ρC←,C)≠1+ρF)/3
[2]    →4,C←T+0.5×(1↓C)-T←¯1↓C
[3]    C←C+((ιρF)-1)×(∧/C=0)∨∧/C=1
[4]    M←(T←+/F×C)÷N←+/F
[5]    V←(+/F×(C-M)*2)÷N-1
[6]    N←M,V,N,T
    ∇

      TIME
24  48  60  72  78  84  90  102  114  138

      ORD
5  13  13  14  17  12  15  7  4

      TIME GST ORD
79.11  400.8463636  100  7911
```

INTOHOW
R←F INTO X
05/01/70
CONFIDENCE CODE: C
1-ORIGIN INDEXING
DR.G.H.MCLAUGHLIN
NEWHOUSE COMMUNICATIONS CENTER, SYR. UNIV. X2747

FUNCTION DESCRIPTION

INTO OUTPUTS A FREQUENCY TABLE IN THE FORM OF A FOUR-COLUMN MATRIX GIVEN TWO ARGUMENTS, ONE DEFINING THE CLASSES AND FREQUENCIES OF AN EXISTING DISTRIBUTION, THE OTHER DEFINING THE CLASS BOUNDS REQUIRED IN THE RESULTANT. INTO IS USED FOR CHANGING THE CLASS BOUNDS IN A FREQUENCY TABLE OF THE FORM OUTPUT BY THE FUNCTION FQ . THE NUMBER OF CLASSES MAY BE REDUCED OR LEFT THE SAME, BUT THEY CANNOT BE INCREASED. THE RESULTANT OF INTO HAS THE SAME FORM AS THAT OF FQ .

IT IS ASSUMED THAT THE VALUES IN EACH ORIGINAL CLASS ARE CONCENTRATED AT THE MIDPOINT.

IN THE DESCRIPTION BELOW IT IS ASSUMED THAT INTO IS TO OPERATE ON SOME TABLE T ORIGINALLY OUTPUT BY FQ .

FUNCTION SYNTAX: R←F INTO X

RESULTANT - R:

THE COLUMNS OF THE RESULTANT R CONTAIN THE FOLLOWING VALUES:
R[;1] LOWER BOUNDS
R[;2] UPPER BOUNDS
R[;3] MIDPOINTS
R[;4] FREQUENCIES

LEFT ARGUMENT - F:

MUST BE EITHER T[;3],T[;4] (I.E. A VECTOR OF CLASS MIDPOINTS CATENATED WITH A VECTOR OF FREQUENCIES)
OR T[;1],T[(ρT)[2];2],T[;4] (I.E. A VECTOR OF LOWER CLASS BOUNDS IN INCREASING ORDER CATENATED WITH THE HIGHEST CLASS BOUND CATENATED WITH A VECTOR OF FREQUENCIES)

RIGHT ARGUMENT - X:

MUST BE <u>EITHER</u> A VECTOR OF AT LEAST FOUR LOWER CLASS BOUNDS IN INCREASING ORDER FOLLOWED BY THE GREATEST UPPER BOUND IN T SUCH THAT
ITS FIRST VALUE IS THE LOWEST BOUND IN T
AND THAT IT HAS NO MORE VALUES THAN 1+ρ*T*[;1]
<u>OR</u> A VECTOR OF THE FOUR VALUES

```
X[1]  T[1;1]  (I.E. THE LEAST CLASS BOUND)
X[2]  0
X[3]  NUMBER OF CLASSES  (NOT GREATER THAN 1+(ρT)[2] )
X[4]  T[(ρT)[2];2]  (I.E. THE GREATEST CLASS BOUND)
```

SUBFUNCTIONS REQUIRED:

SUBFUNCTION	*DESCRIPTION*
FQ	*OUTPUTS A FREQUENCY TABLE*

FUNCTION OUTPUT:

RESULTANT R ONLY

```
      ∇INTO[⎕]∇
    ∇ F←X INTO B;S;I;R
[1]     R←(S←⌈0.5×⍴X)↑X
[2]     →((⍴S←S↓X)=⍴R)/L1
[3]     R←K+0.5×(1↓R)-K←¯1↓R
[4]   L1:F←B FQ R,R
[5]     R←F[;4]÷2
[6]     X←⍴I←K←1
[7]     →(R[I]≠0)/LA
[8]     X←X,0
[9]     →1+LA
[10]  LA:X←X,+/S[⍳R[I]+K-1]
[11]    K←K+R[I]
[12]    →((⍴R)≥I←I+1)/LA
[13]    F[;4]←X-0,¯1↓X
    ∇

      TIME
24  48  60  72  78  84  90  102  114  138

      ORD
5  13  13  14  17  12  15  7  4

      (TIME,ORD) INTO 24,0,4,138

    24                 52.5                38.25               5
    52.5               81                  66.75              40
    81                109.5                95.25              51
   109.5              138                 123.75               4

      (TIME,ORD) INTO 0,20×⍳7

     0                 20                  10                  0
    20                 40                  30                  5
    40                 60                  50                 13
    60                 80                  70                 27
    80                100                  90                 44
   100                120                 110                  7
   120                140                 130                  4

      (36,54,66,75,81,87,96,108,126,ORD) INTO 24,48,72,96,120,138

    24                 48                  36                  5
    48                 72                  60                 26
    72                 96                  84                 43
    96                120                 108                 22
   120                138                 129                  4
```

Z←INVNORM PROB
05/01/70
CONFIDENCE CODE: C
1-*ORIGIN INDEXING*

DR.G.H.MCLAUGHLIN
NEWHOUSE COMMUNICATIONS CENTER, SYR. UNIV. X2747

FUNCTION DESCRIPTION

INVNORM CALCULATES NORMAL DEVIATES CORRESPONDING TO PROBABILITIES IN THE RANGE OF 0≥*PROB*<1. *INVNORM EMBODIES A POLYNOMIAL APPROXIMATION TAKEN FROM HASTINGS* ***APPROXIMATIONS FOR COMPUTERS***. *THE RESULTANT IS GENERALLY ACCURATE TO THREE DECIMAL PLACES.*

FUNCTION SYNTAX: *Z←INVNORM PROB*

RESULTANT - Z:

HAS THE SAME DIMENSION AS THE ARGUMENT PROB

RIGHT ARGUMENT - PROB:

MUST BE A SCALAR ***OR*** *VECTOR WITH NO VALUE LESS THAN* 0 *NOR EQUAL TO OR GREATER THAN* 1

FUNCTION OUTPUT:

RESULTANT PROB ONLY

```
      ∇INVNORM[⎕]∇
    ∇ Z←INVNORM PROB;E;Z
[1]   PROB←÷PROB-0.5<PROB
[2]   E←(⍟PROB*2)*0.5
[3]   Z←1+(1.432788×E)+(0.189269×E*2)+(0.001308×E*3)
[4]   Z←(×-PROB)×E-((2.515517+(0.801853×E)+(0.010328×E*2))÷Z)
    ∇

      PNOR
0.5  0.8413446736  0.9772497307  0.9986501861  0.9999682109

      INVNORM PNOR
¯0.0003988186724  1.000398861  2.000862549  3.000747239
      3.9995412
      INVNORM 1-PNOR
¯0.0003988186724  ¯1.000398861  ¯2.000862549  ¯3.000747239
      ¯3.9995412
```

MANHOW
R←N MAN W
06/05/70
CONFIDENCE CODE: C
1-ORIGIN INDEXING
DR.G.H.MCLAUGHLIN
NEWHOUSE COMMUNICATIONS CENTER, SYR. UNIV. X2747

FUNCTION DESCRIPTION

MAN COMPUTES THE MANN-WHITNEY U STATISTIC AND ITS ONE-TAILED PROBABILITY. THE Z STATISTIC FROM WHICH THE PROBABILITY IS CALCULATED BY A NORMAL APPROXIMATION IS CORRECTED FOR TIES. IF EITHER ARGUMENT HAS 20 OR FEWER VALUES THE SIGNIFICANCE OF U IS BETTER DETERMINED FROM TABLES [E.G. IN SIEGEL'S NON-PARAMETRIC STATISTICS]

FUNCTION SYNTAX: R←N MAN W

RESULTANT - R:

IS A VECTOR GIVING THE JOINT RANK ORDERING OF N AND W

LEFT ARGUMENT - N:

MUST BE A VECTOR OF RAW SCORES

RIGHT ARGUMENT - W:

MUST BE A VECTOR OF RAW SCORES. ρN MUST EQUAL ρW

SUBFUNCTIONS REQUIRED:

SUBFUNCTION	DESCRIPTION
RANK	JOINTLY RANK ORDERS THE ARGUMENTS AND CALCULATES THE NUMBERS OF TIED VALUES
NORMAL	COMPUTES PROBABILITY OF U

FUNCTION OUTPUT:

IN ADDITION TO THE RESULTANT, MAN OUTPUTS THE VALUES LABELLED
U:
Z:
PROBABILITY:

```
      ∇MAN[⎕]∇
    ∇ R←N MAN W;A;B;C;U
[1]    C←(A←⍴N)×B←⍴W
[2]    N←RANK N,W
[3]    W←(0≠N[1])↓(1+N[1])↑N
[4]    U←A↑R←(1+N[1])↓N
[5]    U←C+((A×A+1)÷2)-+/U
[6]    'U: ';U←U⌊C-U
[7]    U←U-C÷2
[8]    'Z: ';U←U÷((C÷N×N-1)×(((N*3)-N←A+B)÷12)-+/((W*3)-W)÷12)*
       0.5
[9]    'PROBABILITY: ';NORMAL U
    ∇

      Y
13  12  12  10  10  10  10  9  8  8  7  7  7  7  7  6

      S
17  16  15  15  15  14  14  14  13  13  13  12  12  12  12
      11  11  10  10  10  8  8  6

      Y MAN S
U: 64
Z: ¯3.45095466
PROBABILITY: 0.0002793868927
29.5  24.5  24.5  16  16  16  16  12  9.5  9.5  5  5  5
      5  5  1.5  39  38  36  36  36  33  33  33  29.5
      29.5  29.5  24.5  24.5  24.5  24.5  20.5  20.5  16
      16  16  9.5  9.5  1.5


      (78,64,75,45,82) MAN 110,70,53,51
U: 9
Z: ¯0.2449489743
PROBABILITY: 0.403247936
7  4  6  1  8  9  5  3  2
```

M←MODE X
04/08/70
CONFIDENCE CODE: C
1-ORIGIN INDEXING
PROF. G. HARRY MCLAUGHLIN
16 NEWHOUSE COMMUNICATIONS CENTER, SYR. UNIV. X2747

FUNCTION DESCRIPTION

MODE CALCULATES THE MODE(S), IF ANY, OF A VECTOR OF RAW DATA. IT DOES NOT INVOLVE MATRIX PRODUCTION, SO IT CAN BE SAFELY APPLIED TO VERY LARGE VECTORS.

FUNCTION SYNTAX: M←MODE X

RESULTANT - M:

IS THE (SCALAR) MODE, IF X IS UNIMODAL
OR A VECTOR OF MODES, IF X IS MULTIMODAL
OR THE EMPTY VECTOR, IF X HAS NO MODE

RIGHT ARGUMENT - X:

MUST BE A VECTOR OF RAW DATA

FUNCTION OUTPUT:

RESULTANT M ONLY

```
      ∇MODE[⎕]∇
    ∇ M←MODE X;N;V
[1]   V←(N←0)×⍳⍴X←X[⍋X]
[2]   M←V,0×⍳N
[3]   →(∨/V←((-N)↓X)=(N←N+1)↓X)/2
[4]   M←M/X
    ∇
      MODE 99,⍳100
99

      MODE 1,4,2,4,3,5,3
3  4
```

M←MVNT X
05/01/70
CONFIDENCE CODE: C
1-*ORIGIN INDEXING*
DR.G.H.MCLAUGHLIN
NEWHOUSE COMMUNICATIONS CENTER, SYR. UNIV. X2747

FUNCTION DESCRIPTION

MVNT CALCULATES THE MEAN(S), VARIANCE(S), NUMBER(S) OF VALUES AND THEIR SUMS FROM EITHER A VECTOR OR A MATRIX OF RAW DATA.

FUNCTION SYNTAX: *M←MVNT X*

RESULTANT - M:

IS A MATRIX OF 4 *COLUMNS AND AS MANY ROWS AS THERE ARE SETS OF DATA IN M . THE COLUMNS CONSIST OF THE FOLLOWING VALUES:*
M[;1] *MEANS*
M[;2] *VARIANCES*
M[;3] *NUMBERS OF VALUES*
M[;4] *SUMS OF VALUES*

RIGHT ARGUMENT - X:

MUST BE __*EITHER*__ *A VECTOR CONSISTING OF A SINGLE SET OF RAW DATA* __*OR*__ *A MATRIX, EACH ROW OF WHICH CONSISTS OF A SEPARATE SET OF DATA*

FUNCTION OUTPUT:

RESULTANT M ONLY

```
      ∇MVNT[⎕]∇
    ∇ M←MVNT X;V;T;N
[1]   V←(+/(X-(ρX)ρ(M←(T←+/X)÷N)∘.×Nρ1)*2)÷(N←(ρX)[ρρX])-1
[2]   M←⍉(4,ρM)ρM,V,(((ρ,X)÷N)ρN),T
    ∇

      ⎕←DNOS←(0,1) DIST NOS
0  1  3  4  4  4  4  4  4  5  5  5  5  5  5  6  6  6  6  6
      6  7  7  7  7  7  7  7  7  8  8  8  8  8  9  9  9  9
      9  10  10  11  11  11  12  12  13  14  15  15

      MVNT DNOS

     7.38            10.85265306        50              369

      MVNT(5,4)ρι20

     2.5              1.666666667        4               10
     6.5              1.666666667        4               26
    10.5              1.666666667        4               42
    14.5              1.666666667        4               58
    18.5              1.666666667        4               74
```

NBINHOW
N←P NBIN K
05/19/70
CONFIDENCE CODE: C
1-ORIGIN INDEXING
DR.G.H.MCLAUGHLIN
NEWHOUSE COMMUNICATIONS CENTER, SYR. UNIV. X2747

FUNCTION DESCRIPTION

NBIN COMPUTES WITH FULL ACCURACY SUCCESSIVE TERMS OF THE NEGATIVE BINOMIAL PROBABILITY DISTRIBUTION, I.E. THE EXPANSION OF (P⋆K)×-P⋆-K

FUNCTION SYNTAX: N←P NBIN K

RESULTANT - N:

IS A VECTOR OF N TERMS OF THE NEGATIVE BINOMIAL DISTRIBUTION

LEFT ARGUMENT - P:

MUST BE THE VALUE OF THE PARAMETER P

RIGHT ARGUMENT - K:

MUST BE A VECTOR OF TWO VALUES
K[1] THE VALUE OF THE PARAMETER K
K[2] N, THE NUMBER OF TERMS TO BE EVALUATED

FUNCTION OUTPUT:

ONLY THE RESULTANT N

```
      ∇NBIN[⎕]∇
    ∇ N←P NBIN K;Q
[1]   N←(N!N+K[1]-1)×(P⋆K[1])×(1-P)⋆N←¯1+⍳K[2]
    ∇

      .9 NBIN 5,6
0.59049  0.295245  0.0885735  0.02066715  0.00413343  0.0007440174
```

NEGBINHOW

N←R NEGBIN F

05/15/70

CONFIDENCE CODE: C

1-ORIGIN INDEXING

DR.G.H.MCLAUGHLIN

NEWHOUSE COMMUNICATIONS CENTER, SYR. UNIV. X2747

FUNCTION DESCRIPTION

FOR A GIVEN FREQUENCY DISTRIBUTION, NEGBIN OUTPUTS DESCRIPTIVE STATISTICS. FROM THESE IT ESTIMATES THE PARAMETERS P AND K FOR A NEGATIVE BINOMIAL DISTRIBUTION. IT THEN CALCULATES THE RESULTANT EXPECTED DISTRIBUTION WHICH IS TESTED FOR GOODNESS OF FIT TO THE OBSERVED DISTRIBUTION BY THE CHI-SQUARED TEST. IF NECESSARY TO MEET THE REQUIREMENTS OF THE TEST, THE FREQUENCY CLASSES ARE CONFLATED TO GIVE A TOTAL OF N CLASSES. N-3 DEGREES OF FREEDOM ARE USED BECAUSE P , K AND A SCALING FACTOR ARE ESTIMATED FROM THE OBSERVATIONS.

P AND K ARE, IN ANY CASE, ESTIMATED BY THE MOMENTS METHOD. IF R IS 0, MAXIMUM LIKELIHOOD ESTIMATORS ARE THEN CALCULATED BY AN ADAPTATION OF MR. CHRIS VANIER'S NEWTON-RAPHSON FUNCTION. IF K DOES NOT CONVERGE WITHIN A TOLERANCE OF .001 AFTER 5 ITERATIONS, THE MOMENTS ESTIMATES ARE USED.

FUNCTION SYNTAX: N←R NEGBIN F

RESULTANT - N:

IS A VECTOR OF EXPECTED FREQUENCIES HAVING A NEGATIVE BINOMIAL DISTRIBUTION WITH PARAMETERS P AND K ESTIMATED FROM THE DISTRIBUTION DEFINED BY THE ARGUMENTS. THE FREQUENCIES, WHICH TOTAL THOSE OF THE GIVEN DISTRIBUTION, ARE GROUPED WITHIN THE CLASSES DEFINED BY R.

LEFT ARGUMENT - R:

MUST BE 0 , IF MAXIMUM LIKELIHOOD ESTIMATORS ARE TO BE CALCULATED [WARNING: THIS CALCULATION IS HIGHLY ITERATIVE]
OTHERWISE R MAY BE (⍳⍴F)-1 [I.E. A VECTOR OF MIDPOINTS OF CLASSES WITH UNIT WIDTH]
OR A VECTOR OF LOWER CLASS BOUNDS, STARTING WITH -0.5, FOLLOWED BY THE GREATEST UPPER BOUND.

RIGHT ARGUMENT - F:

MUST BE A VECTOR OF FREQUENCIES. IF R IS 0 *OR* (ιρ*F*)-1, *THEN F MUST GIVE FREQUENCIES FOR* 0,1,2,3... *EVENTS. IF R CONSISTS OF BOUNDS, F MUST HAVE A VALUE FOR EACH CLASS DEFINED* [*I.E.* ρ*F MUST EQUAL* (ρ*R*)-1].

SUBFUNCTIONS REQUIRED:

SUBFUNCTION	*DESCRIPTION*
GST	*CALLED BY GSTATISTICS TO CALCULATE DESCRIPTIVE STATISTICS FROM GROUPED DATA*
GSTATISTICS	*DISPLAYS DESCRIPTIVE STATISTICS*
NBIN	*OUTPUTS N UNROUNDED VALUES OF A NEGATIVE BINOMIAL DISTRIBUTION GIVEN N , P AND K*
CHI	*CALCULATES CHI-SQUARED, USING A GLOBAL VARIABLE ESTIMATES WHICH IS SET AUTOMATICALLY BY NEGBIN*
CHISQ	*CALLED BY CHI TO COMPUTE THE PROBABILITY OF GIVEN CHI-SQUARED AND D.F. VALUES*
NORMAL	*CALLED BY CHISQ TO CALCULATE THE PROBABILITY OF A NORMAL DEVIATE, USING A SIXTH-ORDER POLYNOMIAL APPROXIMATION*

FUNCTION OUTPUT:

IN ADDITION TO RETURNING THE RESULTANT, NEGBIN PRINTS OUT THESE ITEMS, FULLY LABELLED:

1. *MEAN, S.E., S.D. AND NUMBER OF VALUES OF F*
2. *EITHER MOMENTS METHOD ESTIMATES OF P AND K OR THE MESSAGE 'VARIANCE≤MEAN, SO DISTRIBUTION IS NOT NEGATIVE BINOMIAL' (IN WHICH CASE THE FUNCTION BRANCHES OUT AND THE RESULTANT IS AN EMPTY VECTOR)*
3. *IF R=*0, *EITHER MAXIMUM LIKELIHOOD ESTIMATES OF P AND K OR THE MESSAGE 'MAXIMUM LIKELIHOOD ESTIMATES UNOBTAINABLE'*
4. *CALCULATED CHI-SQUARE, ITS DEGREES OF FREEDOM, AND ITS PROBABILITY, GENERALLY ACCURATE TO AT LEAST THREE FIGURES.*

```
      ∇NEGBIN[⎕]∇
    ∇ N←R NEGBIN F;J;U;S;T;P;I;C;K;M;E;L;V;ESTIMATES
[1]    N←R GSTATISTICS F
[2]    L←N[3]
[3]    →(1≥P←(M←N[1])÷V←N[2])/ES
[4]    'VARIANCE ≤ MEAN, SO DISTRIBUTION IS NOT NEGATIVE BINOMIAL'
[5]    →0
[6]   ES:'MOMENTS METHOD  (P ';P
[7]    '  ESTIMATES      (K ';I←K←M×P÷1-P
[8]    N←F[1]
[9]    C←0×ρF←1↓F
[10]   →(1≠ρR←,R)/CA
[11]  L1:E←K
[12]   J←ρF
[13]   Z←L×⍟U←1+M÷K+S←0
[14]   V←-L×M÷(K*2)×U
[15]  L2:Z←Z-(S←S+F[J])÷T←K+J-1
[16]   V←V+S÷T*2
[17]   →(1≤J←J-1)/L2
[18]   →((5<C←C+1),0.001≤|E-K←E+(-Z)÷V)/NO,L1
[19]   'MAX LIKELIHOOD  (P ';P←K÷M+K
[20]   '  ESTIMATES     (K ';K
[21]   →CA
[22]  NO:K←I
[23]   'MAXIMUM LIKELIHOOD ESTIMATES UNOBTAINABLE'
[24]  CA:N←L×N←P NBIN K,(⌊R[ρR])⌈ρF←N,F
[25]   →(1=R←ρR)/27
[26]   N←+/(R,(ρN)÷R←R-R>ρF)ρN
[27]   ESTIMATES← 2 2 2
[28]   N CHI F
[29]   N←⌊0.5+N
    ∇
      GOALS
95  158  108  63  40  9  5  2

      0 NEGBIN GOALS
MEAN                    1.691666667
STANDARD ERROR          0.06347505478
STANDARD DEVIATION      1.390668774
NUMBER OF VALUES        480
MOMENTS METHOD    (P    0.8747166349
  ESTIMATES       (K    11.81105706
MAX LIKELIHOOD    (P    0.8758135845
  ESTIMATES       (K    11.93032782
CHI-SQUARED             5.845398145
DEGREES OF FREEDOM      5
PROBABILITY             0.5579131011
99  146  117  68  31  12  4  1

      (0,⍳7) NEGBIN GOALS
MEAN                    1.691666667
STANDARD ERROR          0.06347505478
STANDARD DEVIATION      1.390668774
NUMBER OF VALUES        480
MOMENTS METHOD    (P    0.8747166349
  ESTIMATES       (K    11.81105706
CHI-SQUARED             5.832759329
DEGREES OF FREEDOM      5
PROBABILITY             0.5594074321
99  146  117  68  31  12  4  1
```

PROB←NORMAL Z
05/19/70
CONFIDENCE CODE: C
1-ORIGIN INDEXING
DR.G.H.MCLAUGHLIN
NEWHOUSE COMMUNICATIONS CENTER, SYR. UNIV. X2747

FUNCTION DESCRIPTION

NORMAL COMPUTES THE CUMULATIVE PROBABILITY DISTRIBUTION FUNCTION OF A STANDARDIZED NORMAL VARIABLE. IT USES A SIXTH-ORDER POLYNOMIAL APPROXIMATION TAKEN FROM HASTINGS' APPROXIMATIONS FOR COMPUTERS WHICH IS ACCURATE TO AT LEAST FOUR DECIMAL PLACES IN THE RANGE ¯4<Z<4.

FUNCTION SYNTAX: PROB←NORMAL Z

RESULTANT - PROB:

IS A VECTOR OF PROBABILITIES CORRESPONDING TO THE VALUES OF Z .

RIGHT ARGUMENT - Z:

MUST BE A SCALAR OR A VECTOR OF Z VALUES

FUNCTION OUTPUT:

RESULTANT PROB ONLY

```
      ∇NORMAL[⎕]∇
    ∇ PROB←NORMAL Z;C
[1]   C← 0.04986734697 0.02114100615 0.00327762324
      3.8003575E¯5 4.889063564E¯5 5.382975E¯6
[2]   PROB←((Z<0)×1-C)+(Z≥0)×C←1-0.5×(1++/(((ρZ),6)ρC)×(|Z)∘.*ι
      6)*¯16
    ∇
      ⎕←PNOR←NORMAL 0,ι4
0.5  0.8413446736  0.9772497307  0.9986501861  0.9999682109

      NORMAL -0,ι4
0.5  0.1586553264  0.02275026929  0.001349813929  3.178910037E¯5
```

X←C NORMFIT OB
06/05/70
CONFIDENCE CODE: *C*
1-*ORIGIN INDEXING*
DR.G.H.MCLAUGHLIN
NEWHOUSE COMMUNICATIONS CENTER, SYR. UNIV. X2747

FUNCTION DESCRIPTION

FOR A GIVEN FREQUENCY DISTRIBUTION, NORMFIT OUTPUTS DESCRIPTIVE STATISTICS. IT THEN CALCULATES THE RESULTANT NORMAL DISTRIBUTION, THE MEAN AND VARIANCE OF WHICH ARE ESTIMATED FROM THE GIVEN DISTRIBUTION. THE OBSERVED DISTRIBUTION IS THEN TESTED FOR GOODNESS OF FIT TO THE NORMAL DISTRIBUTION BY THE CHI-SQUARED TEST. IF NECESSARY TO MEET THE REQUIREMENTS OF THE TEST, THE FREQUENCY CLASSES ARE CONFLATED TO GIVE A TOTAL OF N CLASSES. N-3 *DEGREES OF FREEDOM ARE USED BECAUSE THE TWO PARAMETERS OF THE NORMAL DISTRIBUTION AND A SCALING FACTOR ARE ESTIMATED FROM THE OBSERVATIONS.*

FUNCTION SYNTAX: *X←C NORMFIT OB*

RESULTANT - X:

IS THE VECTOR OF ⍴OB NORMALLY DISTRIBUTED FREQUENCIES AT EITHER THE UPPER CLASS BOUNDS OR THE CLASS MIDPOINTS, WHICHEVER IS DEFINED BY C .

LEFT ARGUMENT - C:

MUST BE EITHER A VECTOR OF LOWER CLASS BOUNDS, IN INCREASING ORDER, FOLLOWED BY THE HIGHEST CLASS BOUND, OR A VECTOR OF CLASS MIDPOINTS IN INCREASING ORDER.

RIGHT ARGUMENT - OB:

MUST BE A VECTOR OF FREQUENCIES, ONE FOR EACH CLASS DEFINED BY C .

SUBFUNCTIONS REQUIRED:

SUBFUNCTION	*DESCRIPTION*
GST	*CALLED BY GSTATISTICS TO CALCULATE DESCRIPTIVE STATISTICS FROM GROUPED DATA*
GSTATISTICS	*DISPLAYS DESCRIPTIVE STATISTICS*
CHI	*CALCULATES CHI-SQUARED, USING A GLOBAL VARIABLE ESTIMATES WHICH IS SET AUTOMATICALLY BY NORMFIT*
CHISQ	*CALLED BY CHI TO COMPUTE THE PROBABILITY OF GIVEN CHI-SQUARED AND D.F. VALUES*
NORMAL	*CALCULATES THE PROBABILITY OF A NORMAL DEVIATE, USING A SIXTH-ORDER POLYNOMIAL APPROXIMATION*

FUNCTION OUTPUT:

IN ADDITION TO RETURNING THE RESULTANT, NORMFIT PRINTS OUT THESE ITEMS, FULLY LABELLED:
MEAN, S.E., S.D. AND NUMBER OF VALUES OF OB;
CALCULATED CHI-SQUARE, ITS DEGREES OF FREEDOM, AND ITS PROBABILITY, GENERALLY ACCURATE TO AT LEAST THREE FIGURES.

```
      ∇NORMFIT[⎕]∇
    ∇ X←C NORMFIT OB;S;ESTIMATES
[1]   S←C GSTATISTICS OB
[2]   X←NORMAL((((ρC)≠ρOB)↓C)-S[1])÷S[2]*0.5
[3]   X←(X,S)-0,X←¯1↓X×S←+/OB
[4]   ESTIMATES← 2 2 2
[5]   X CHI OB
    ∇
      TIME
24  48  60  72  78  84  90  102  114  138

      ORD
5  13  13  14  17  12  15  7  4

      TIME NORMFIT ORD
MEAN                79.11
STANDARD ERROR      2.002114791
STANDARD DEVIATION  20.02114791
NUMBER OF VALUES    100
CHI-SQUARED         5.749666001
DEGREES OF FREEDOM  6
PROBABILITY         0.6752496197
6.010920492  10.98085459  19.13302898  11.66454929  11.85846989
      11.02752222  16.67877  8.576204911  4.069679633
```

```
T←RANK  V
05/01/70
CONFIDENCE CODE:  C
1-ORIGIN INDEXING
DR.G.H.MCLAUGHLIN
NEWHOUSE COMMUNICATIONS CENTER, SYR. UNIV.  X2747
```

FUNCTION DESCRIPTION

RANK CALCULATES THE RANK ORDER OF A VECTOR OF RAW SCORES AND THE NUMBERS OF TIES IN THAT ORDERING.

FUNCTION SYNTAX: T←RANK V

RESULTANT - T:

IS A VECTOR, THE LAST ρV MEMBERS OF WHICH GIVE THE RANK ORDER OF V .
T[1] IS THE NUMBER OF GROUPS OF TIED VALUES: IF THERE ARE NO TIES, T[1] IS 0 . THE NEXT T[1] NUMBERS, IF ANY, ARE THE NUMBERS OF VALUES IN EACH TIED GROUP.

RIGHT ARGUMENT - V:

MUST BE A VECTOR, WHICH CAN CONSIST OF ANY VALUES IN ANY ORDER

FUNCTION OUTPUT:

RESULTANT T ONLY
NOTE- THE VARIOUS COMPONENTS OF T MAY BE PICKED OUT THUS:
(1+T[1])↓T GIVES THE RANKINGS OF V
T[1] GIVES THE NUMBER OF TIES
(0≠T[1])↓(1+T[1])↑T GIVES THE NUMBER OF VALUES IN EACH TIE

```
      ∇RANK[⎕]∇
    ∇ T←RANK V;Y;W;R;S;X;K
[1]   W←⍋Y←V[R←⍋V]
[2]   K←1+T←0
[3]   →(∧/R=⌽⍒V)/EN
[4]   S←R[ρR←⍳ρV]
[5]  L1:X←Y∊Y[K]
[6]   T←T,ρX←X/X×R
[7]   W[K]←Xρ+/W[K←K+¯1+⍳X]÷X←ρ,X
[8]   →(S≥K←K[ρK]+1)/L1
[9]   T←(ρT),T←(1<T)/T
[10] EN:T←T,W[⍋⍋V]
    ∇

      RANK 5,5,8,⍳9
2  3  2  6  6  10.5  1  2  3  4  6  8  9  10.5  12
```

RHOHOW
R←X RHO Y
06/05/70
CONFIDENCE CODE: C
1-*ORIGIN INDEXING*
DR.G.H.MCLAUGHLIN
*NEWHOUSE COMMUNICATIONS CENTER, SYR. UNIV. X*2747

FUNCTION DESCRIPTION

RHO COMPUTES THE SPEARMAN RANK CORRELATION COEFFICIENT CORRECTED FOR TIES. IT ALSO EVALUATES THE PROBABILITY OF THE OBSERVED RHO VALUE BY MEANS OF A ONE-TAILED T TEST. IF EITHER ARGUMENT HAS FEWER THAN 10 *VALUES, THE SIGNIFICANCE OF RHO IS BETTER DETERMINED FROM TABLES [E.G. IN SIEGEL'S NON-PARAMETRIC STATISTICS].*

FUNCTION SYNTAX: R←X RHO Y

RESULTANT - R:

IS A 2-*COLUMN MATRIX GIVING THE RANK ORDER OF THE LEFT ARGUMENT ON THE LEFT, AND THE RANK ORDER OF THE RIGHT ARGUMENT ON THE RIGHT.*

LEFT ARGUMENT - X:

MUST BE A VECTOR OF SCORES

RIGHT ARGUMENT - Y:

MUST BE A VECTOR OF SCORES. ⍴X MUST EQUAL ⍴Y.

SUBFUNCTIONS REQUIRED:

SUBFUNCTION	*DESCRIPTION*
RANK	*RANK ORDERS THE ARGUMENTS AND CALCULATES THE NUMBER OF THE VALUES*
FRATIO	*PERFORMS A T-TEST*

FUNCTION OUTPUT:

IN ADDITION TO THE RESULTANT, RHO OUTPUTS THE VALUES LABELLED
RHO:
T:
PROBABILITY:
HOWEVER, IF RHO IS 1 *OR* -1 , *THE T STATISTIC AND THE PROBABILITY ARE NOT GIVEN.*

```
      ∇RHO[⎕]∇
    ∇ R←X RHO Y;N;NX;NY
[1]   →((⍴X)≠N←⍴Y)/LA
[2]   X←RANK X
[3]   Y←RANK Y
[4]   NX←(0≠X[1])↓(1+X[1])↑X
[5]   NY←(0≠Y[1])↓(1+Y[1])↑Y
[6]   NX←(R←((N*3)-N)÷12)-+/((NX*3)-NX)÷12
[7]   NY←R-+/((NY*3)-NY)÷12
[8]   R←+/((X←(1+X[1])↓X)-(Y←(1+Y[1])↓Y))*2
[9]   'RHO: ';R←(NX+NY-R)÷2×(NX×NY)*0.5
[10]  →(1=|R)/EN
[11]  'T: ';R←R×((N-2)÷1-R*2)*0.5
[12]  'PROBABILITY: ';0.5×FRATIO 1,(N-2),R*2
[13] EN:R←⍉(2,N)⍴X,Y
[14]  →0
[15] LA:'SAMPLE SIZES UNEQUAL: TRY AGAIN'
    ∇

      YIELD
0  0  1  1  3  4  5  6  7  8  8  12

      STRIVE
42  46  39  37  65  88  86  56  62  92  54  81

      YIELD RHO STRIVE
RHO: 0.6151227852
T: 2.46716356
PROBABILITY: 0.01598486878

      1.5          3
      1.5          4
      3.5          2
      3.5          1
      5            8
      6           11
      7           10
      8            6
      9            7
     10.5         12
     10.5          5
     12            9

      YIELD RHO STRIVE,100
SAMPLE SIZES UNEQUAL: TRY AGAIN

      (8,7,6) RHO ⍳3
RHO: ¯1

  3  1
  2  2
  1  3
```

LIT
06/05/70
CONFIDENCE CODE: C
1-ORIGIN INDEXING
DR.G.H.MCLAUGHLIN
NEWHOUSE COMMUNICATIONS CENTER, SYR. UNIV. X2747

FUNCTION DESCRIPTION

LIT IS A CONVERSATIONAL FUNCTION USED TO PREPARE AND/OR CORRECT A LENGTHY CHARACTER VECTOR, WHICH CAN BE USED AS AN ARGUMENT BY THE FUNCTION TAB TO PROVIDE ROW LABELS FOR A TABULATION. EACH CHARACTER STRING WHICH IS TO PRINT AS A LINE TERMINATES WITH THE CHARACTER.

FUNCTION SYNTAX: LIT

INPUT AT EXECUTION TIME:

LIT CAN BE USED TO EDIT AN ORDINARY CHARACTER MATRIX, BUT A VECTOR TO BE EDITED MUST HAVE CONSTITUENT STRINGS TERMINATING WITH ∘ .

FUNCTION OUTPUT:

THE (IMPLICIT) RESULTANT WILL ALWAYS BE A VECTOR. THE USE OF LIT CAN BEST BE UNDERSTOOD BY PREPARING A TRIAL VECTOR. TO START, TYPE LIT.

```
      ∇LIT[⎕]∇
    ∇ LIT;J;K;L;S;P;Q;R;T;V;L;K;V
[1]    'TO SKIP DETAILED INSTRUCTIONS, TYPE  1  ; OTHERWISE TYPE  0'
[2]    →(P←⎕)/PD
[3]    'AN EXISTING CHARACTER VECTOR CAN BE EDITED ONLY IF IT WAS'
[4]    'PREPARED USING  LIT.'
[5]   PD:'TO EDIT AN EXISTING ARRAY, TYPE ITS NAME.  OTHERWISE TYPE 0'
[6]    →(((~P)×~S),(P×~S),(S×~P),P×S←0=ρR←ρV←⎕)/RF,PF,GO,PN
[7]    V←,(¯2 ¯1)⍉((1+R[2],R[1])ρ(R[1]ρ'∘'),⍉V
[8]    →(P,~P)/PF,RF
[9]   GO:'PRESS RETURN KEY AFTER TYPING EACH STRING OF CHARACTERS'
[10]   'WHICH IS TO PRINT AS A LINE.  IF YOU SPOT AN ERROR BEFORE'
[11]   'PRESSING THE RETURN KEY, BACKSPACE TO THE ERROR, PRESS THE'
[12]   'ATTENTION KEY AND RETYPE CORRECT ENTRIES FROM THAT POINT.'
[13]   'OTHER CORRECTIONS CAN BE MADE LATER.'
[14]   'IF AN ERROR SIGNAL APPEARS, TYPE  →EN'
[15]  PN:'AFTER ALL ENTRIES HAVE BEEN MADE, TYPE  ⊥'
[16]   V←ρK←L←0
[17]  EN:→(Q←('⊥')≠T[ρT←,⍞])/LN
[18]   →(0=ρ,T←¯1↓T)/VE
[19]  LN:'LINE ';K;' CHARACTERS: ';ρT;'   TOTAL: ';(ρV←V,T,'∘')-K←K+1
[20]   →Q/EN
[21]  VE:→P/PF
[22]  RF:'TO MAKE CORRECTIONS OTHER THAN THE ADDITION OF ENTRIES AT'
[23]   'THE END OF THE VECTOR, YOU MUST REFER TO EACH ENTRY CONCERNED'
[24]   'BY ITS ENTRY NUMBER.'
[25]  PF:'FOR A NUMBERED LIST OF ENTRIES, TYPE  1  ; OTHERWISE  0'
[26]   Q←⎕
[27]  NW:J←ι(ρL←0,L/L×ιρL←V∊'∘')-K←1
[28]   →((P×~Q),(~P)×~Q)/PC,CR
[29]  PR:K;'  ',V[L[K]+ιL[K+1]-L[K]+1]
[30]   →((ρL)>K←K+1)/PR
[31]   →((S=6),P×S≠6)/SW,PC
[32]  CR:'IF N SYMBOLISES AN ORIGINAL ENTRY, AND'
[33]   'NO SYMBOLISES ITS ENTRY NUMBER, TO-'
[34]   '-INSPECT N, TYPE   1,NO'
[35]   '-SUBSTITUTE A NEW ENTRY FOR N, TYPE   2,NO  PRESS RETURN KEY'
[36]   '      AND TYPE THE SUBSTITUTE ENTRY'
[37]   '-DELETE N, TYPE  3,NO'
[38]   '-INSERT ENTRIES BEFORE N, TYPE  4,NO  PRESS RETURN KEY'
[39]   '      AND TYPE ONE OR MORE EXTRA ENTRIES, PRESSING RETURN KEY'
[40]   '      AFTER EACH; WHEN ALL EXTRA ENTRIES HAVE BEEN MADE TYPE⊥'
[41]   '-ADD ENTRIES AFTER THE LAST N, TYPE  5  AND PROCEED AS FOR  4'
[42]   '-OBTAIN A NEW LIST OF NUMBERED ENTRIES, TYPE  6'
[43]   '      (SUCH A LIST IS NEEDED TO CORRECT PREVIOUS CORRECTIONS)'
[44]   'THESE OPERATIONS MAY BE PERFORMED, IN ANY ORDER, AS OFTEN AS'
[45]   'NECESSARY.  TO CONTINUE IF AN ERROR IS SIGNALED, TYPE  →SW'
[46]  PC:'WHEN CORRECTIONS ARE ALL DONE, TYPE  7'
```

```
      ∇LIT[⎕47]∇
[47] SW:→((S=5),(S=6),((0=P)×7=S),(1=P)×7=S←(T←,⎕)[Q←1])/IN,NW,OU,PT
[48]  K←J[R←T[2]]
[49]  →((S=1),(S=2),(S=3),S=4)/SE,SB,DL,IN
[50] SE:V[L[K]+⍳L[K+1]-L[K]+1]
[51]  →SW
[52] SB:V←(L[K]↑V),(T←⍞),(L[K+1]-1)↓V
[53]  →SW,L[K+⍳(ρL)-K]←L[K+⍳(ρL)-K]+(ρT)-L[K+1]-L[K]+1
[54] DL:V←(L[K]↑V),L[K+1]↓V
[55]  L←(K↑L),((K+1)↓L)-L[K+1]-L[K]
[56]  →SW,J[R]←J[R←R+⍳(ρJ)-R]-1
[57] IN:V̲←ρK̲←L̲←0
[58] E̲N̲:→(Q̲←('⊥')≠T[ρT←,⍞])/L̲N̲
[59]  →(0=ρ,T←¯1↓T)/V̲E̲
[60] L̲N̲:'EXTRA LINE ';K̲;' CHARACTERS: ';ρT;'   TOTAL: ';L̲[ρL̲←L̲,ρV̲←V̲,T
      ,'∘']-K̲←K̲+1
[61]  →Q̲/E̲N̲
[62] V̲E̲:→(S=5)/AD
[63]  V←(L[K]↑V),V̲,L[K]↓V
[64]  L←((K-1)↑L),(L̲+L[K]),L̲[ρL̲]+,K↓L
[65]  →SW,J←((R-1)↑J),(R-1)↓J+K̲
[66] AD:V←V,V̲
[67]  L←L,L[ρL]+1↓L̲
[68]  →SW,J←J,J[ρJ]+⍳(ρL̲)-1
[69] OU:'TO SAVE THE VECTOR  V  JUST PREPARED, TYPE A NAME FOR IT'
[70]  'FOLLOWED BY  ←V  THUS: EXAMPLE←V'
[71]  'THEN PRESS THE RETURN KEY, AND TYPE  →';3+⌶26
[72]  'FINALLY, PRESS THE RETURN KEY AND TYPE  )SAVE'
[73] PT:S∆LIT←1+⌶26
[74]  L←J←V←⍳0
```

```
      LIT
TO SKIP DETAILED INSTRUCTIONS, TYPE  1  ; OTHERWISE TYPE  0
⎕:
      1
TO EDIT AN EXISTING ARRAY, TYPE ITS NAME.  OTHERWISE TYPE 0
⎕:
      0
AFTER ALL ENTRIES HAVE BEEN MADE, TYPE  ⊥
TWO
LINE 1 CHARACTERS: 3   TOTAL: 3
THREE
LINE 2 CHARACTERS: 5   TOTAL: 8
THREE
LINE 3 CHARACTERS: 5   TOTAL: 13
FOUR
LINE 4 CHARACTERS: 4   TOTAL: 17
ANOTHER ERROR
LINE 5 CHARACTERS: 13   TOTAL: 30
SIX⊥
LINE 6 CHARACTERS: 3   TOTAL: 33
FOR A NUMBERED LIST OF ENTRIES, TYPE  1  ; OTHERWISE  0
⎕:
      1
1  TWO
2  THREE
3  THREE
4  FOUR
5  ANOTHER ERROR
6  SIX
WHEN CORRECTIONS ARE ALL DONE, TYPE  7
⎕:
      4,1
ONE⊥
EXTRA LINE 1 CHARACTERS: 3   TOTAL: 3
⎕:
      3,3
⎕:
      1,5
ANOTHER ERROR
⎕:
      2,5
FIVE
⎕:
      5
SEVEN
EXTRA LINE 1 CHARACTERS: 5   TOTAL: 5
EIGHT
EXTRA LINE 2 CHARACTERS: 5   TOTAL: 10
⊥
⎕:
      7

LIT[74]
      LABELS←V
      )SAVE
  16.25.10 06/09/70 FUNCTIONS
      →74
      LABELS
ONE∘TWO∘THREE∘FOUR∘FIVE∘SIX∘SEVEN∘EIGHT∘
```

NUM
06/05/70
CONFIDENCE CODE: C
1-ORIGIN INDEXING
DR.G.H.MCLAUGHLIN
NEWHOUSE COMMUNICATIONS CENTER, SYR. UNIV. X2747

FUNCTION DESCRIPTION

NUM IS A CONVERSATIONAL FUNCTION WHICH ASSISTS THE USER TO PREPARE AND/OR CORRECT A LENGTHY NUMERICAL VECTOR. THE INPUT(S) CAN BE SCALARS, VECTORS, OR MATRIXES.

FUNCTION SYNTAX: NUM

FUNCTION OUTPUT:

THE (IMPLICIT) RESULTANT WILL ALWAYS BE A VECTOR, WHICH CAN OF COURSE BE RESHAPED AS A MATRIX. THE USE OF NUM CAN BEST BE UNDERSTOOD BY PREPARING A TRIAL VECTOR. TO START, TYPE NUM.

```
      ∇NUM[⎕]∇
    ∇ NUM;J;K;S;P;Q;R;T;V
[1]    'TO SKIP DETAILED INSTRUCTIONS, TYPE  1  ; OTHERWISE TYPE  0'
[2]    P←⎕
[3]    'TO EDIT AN EXISTING ARRAY, TYPE ITS NAME; OTHERWISE TYPE  *9'
[4]    →((Q×~P),P×Q←(*9)≠(V←,⎕)[1+S←0])/RF,PF
[5]    V←⍳K←0
[6]    →P/PN
[7]    'TYPE ENTRIES WITH A SPACE OR COMMA BETWEEN EACH.  AN ENTRY CAN'
[8]    'BE AN INDIVIDUAL VALUE OR AN ARRAY.  PRESS THE RETURN KEY'
[9]    'BEFORE THE TYPEBALL REACHES THE RIGHT MARGIN.  IF YOU SPOT AN'
[10]   'ERROR BEFORE PRESSING THE RETURN KEY, BACKSPACE TO THE ERROR'
[11]   'PRESS THE ATTENTION KEY, AND RETYPE CORRECT ENTRIES FROM THAT'
[12]   'POINT.  OTHER CORRECTIONS CAN BE MADE LATER.'
[13]   'IF AN ERROR SIGNAL APPEARS, TYPE  →EN'
[14]  PN:'AFTER ENTERING ALL VALUES, TYPE THE THREE SYMBOLS  ,*9'
[15]  EN:V←V,(-Q←T[⍴T]=*9)↓T←,⎕
[16]   'LINE ';K←K+1;' ENTRIES: ';(⍴T)-Q;'   TOTAL: ';⍴V
[17]   →(~Q)/EN
[18]   →P/PF
[19]  RF:'TO MAKE CORRECTIONS, YOU MUST REFER TO EACH VALUE CONCERNED'
[20]   'BY THE ORDINAL NUMBER OF ITS ENTRY.'
[21]  PF:'FOR A NUMBERED LIST OF ENTRIES, TYPE  1  ; OTHERWISE  0'
[22]   Q←⎕
[23]  NW:J←⍳⍴V
[24]   →((P×~Q),(~P)×~Q)/PC,CR
[25]   R←5|⍴V
[26]   1 3 2 ⍉ 3 1 2 ⍉(2,(⌊(⍴V)÷5),5)⍴((-R)↓J),(-R)↓V
[27]   (2,R)⍴((-R)↑J),(-R)↑V
[28]   →((S=6),P×S≠6)/SW,PC
[29]  CR:'IF N SYMBOLISES ONE OF YOUR ORIGINAL ENTRIES,  AND'
[30]   'NQ SYMBOLISES ITS ENTRY NUMBER, TO-'
[31]   '-INSPECT N, TYPE   1, NQ'
[32]   '-SUBSTITUTE A NEW ENTRY FOR N, TYPE'
[33]   '      2,NQ,THE SUBSTITUTE ENTRY'
[34]   '-DELETE N, TYPE  3,NQ'
[35]   '-INSERT ONE OR MORE SUCCESSIVE EXTRA ENTRIES BEFORE N,'
[36]   '      TYPE  4,NQ, EXTRA ENTRIES'
[37]   '-ADD ENTRIES AFTER THE LAST N, TYPE  5, EXTRA ENTRIES'
[38]   '-OBTAIN A NEW LIST OF NUMBERED ENTRIES, TYPE  6'
[39]   '      (SUCH A LIST IS NEEDED TO CORRECT PREVIOUS CORRECTIONS)'
[40]   'THESE OPERATIONS MAY BE PERFORMED, IN ANY ORDER, AS OFTEN AS'
[41]   'NECESSARY.  TO CONTINUE IF AN ERROR IS SIGNALED, TYPE  →SW'
[42]  PC:'WHEN CORRECTIONS ARE ALL DONE, TYPE  7'
[43]  SW:→((S=5),(S=6),(7=P+S),8=P+S←(T←,⎕)[Q←1])/AD,NW,OU,PT
[44]   K←J[R←T[2]]
[45]   →((S=1),(S=2),(S=3),S=4)/SE,SB,DL,IN
[46]  SE:V[K]
[47]   →SW
[48]  SB:→SW,V[K]←T[3]
[49]  DL:V←((K-1)↑V),K↓V
[50]   →SW,J[R]←J[R←R+⍳(⍴J)-R]-1
[51]  AD:→SW,V←V,T←1↓T
[52]  IN:V←((K-1)↑V),(T←2↓T),(K-1)↓V
[53]   →SW,J[R]←J[R←R+0,⍳(⍴J)-R]+⍴T
[54]  OU:'TO SAVE THE VECTOR  V  JUST PREPARED, TYPE A NAME FOR IT'
[55]   'FOLLOWED BY  ←V  THUS: EXAMPLE←V'
[56]   'THEN PRESS THE RETURN KEY, AND TYPE  →';3+⌶26
[57]   'FINALLY, PRESS THE RETURN KEY AND TYPE  )SAVE'
[58]  PT:S∆NUM←1+⌶26
[59]   J←V←⍳0
    ∇
```

```
      NUM
TO SKIP DETAILED INSTRUCTIONS, TYPE  1  ; OTHERWISE TYPE  0
⎕:
      0
TO EDIT AN EXISTING ARRAY, TYPE ITS NAME; OTHERWISE TYPE  *9
⎕:
      *9
TYPE ENTRIES WITH A SPACE OR COMMA BETWEEN EACH.  AN ENTRY CAN
BE AN INDIVIDUAL VALUE OR AN ARRAY.  PRESS THE RETURN KEY
BEFORE THE TYPEBALL REACHES THE RIGHT MARGIN.  IF YOU SPOT AN
ERROR BEFORE PRESSING THE RETURN KEY, BACKSPACE TO THE ERROR
PRESS THE ATTENTION KEY, AND RETYPE CORRECT ENTRIES FROM THAT
POINT.  OTHER CORRECTIONS CAN BE MADE LATER.
IF AN ERROR SIGNAL APPEARS, TYPE  →EN
AFTER ENTERING ALL VALUES, TYPE THE THREE SYMBOLS  ,*9
⎕:
      11 22 33,*9
LINE 1 ENTRIES: 3   TOTAL: 3
TO MAKE CORRECTIONS, YOU MUST REFER TO EACH VALUE CONCERNED
BY THE ORDINAL NUMBER OF ITS ENTRY.
FOR A NUMBERED LIST OF ENTRIES, TYPE  1  ; OTHERWISE  0
⎕:
      0
IF N SYMBOLISES ONE OF YOUR ORIGINAL ENTRIES,  AND
NQ SYMBOLISES ITS ENTRY NUMBER, TO-
-INSPECT N, TYPE   1, NQ
-SUBSTITUTE A NEW ENTRY FOR N, TYPE
     2,NQ,THE SUBSTITUTE ENTRY
-DELETE N, TYPE  3,NQ
-INSERT ONE OR MORE SUCCESSIVE EXTRA ENTRIES BEFORE N,
     TYPE  4,NQ, EXTRA ENTRIES
-ADD ENTRIES AFTER THE LAST N, TYPE  5, EXTRA ENTRIES
-OBTAIN A NEW LIST OF NUMBERED ENTRIES, TYPE  6
     (SUCH A LIST IS NEEDED TO CORRECT PREVIOUS CORRECTIONS)
THESE OPERATIONS MAY BE PERFORMED, IN ANY ORDER, AS OFTEN AS
NECESSARY.  TO CONTINUE IF AN ERROR IS SIGNALED, TYPE  →SW
WHEN CORRECTIONS ARE ALL DONE, TYPE  7
⎕:
      4,1,0
⎕:
      6


     1                2                3                4
     0               11               22               33
⎕:
      7
TO SAVE THE VECTOR  V  JUST PREPARED, TYPE A NAME FOR IT
FOLLOWED BY  ←V  THUS: EXAMPLE←V
THEN PRESS THE RETURN KEY, AND TYPE  →59
FINALLY, PRESS THE RETURN KEY AND TYPE  )SAVE

NUM[59]
      MAT←V
      )SAVE
  16.15.22 06/09/70 FUNCTIONS
      →59
      MAT
0  11  22  33
```

```
      MAT←(3,2)ρ2,3,3,4,9,6
      NUM
TO SKIP DETAILED INSTRUCTIONS, TYPE  1  ; OTHERWISE TYPE  0
⎕:
      1
TO EDIT AN EXISTING ARRAY, TYPE ITS NAME; OTHERWISE TYPE  *9
⎕:
      MAT
FOR A NUMBERED LIST OF ENTRIES, TYPE  1  ; OTHERWISE  0
⎕:
      1

  1  2  3  4  5
  2  3  3  4  9

  6
  6
WHEN CORRECTIONS ARE ALL DONE, TYPE  7
⎕:
      1,5
9
⎕:
      2,5,5
⎕:
      3,2
⎕:
      4,1,1
⎕:
      5,7,8,9
⎕:
      7

NUM[59]
      MAT←V
      )SAVE
  16.20.08 06/09/70 FUNCTIONS
      →59
      MAT
1  2  3  4  5  6  7  8  9
```

L TAB M
06/09/70
CONFIDENCE CODE: C
1-ORIGIN INDEXING
DR.G.H.MCLAUGHLIN
NEWHOUSE COMMUNICATIONS CENTER, SYR. UNIV. X2747

FUNCTION DESCRIPTION

TAB PRINTS OUT A NUMERICAL TABLE WITH CENTERED HEADINGS, ROW LABLES AND A CAPTION AS REQUIRED. BECAUSE THE OUTPUT IS MIXED IT CANNOT BE SAVED, BUT IT IS OFTEN MORE ECONOMICAL TO SAVE THE ARGUMENT OF TAB SEPARATELY AND OBTAIN AN OUTPUT USING THIS FUNCTION THAN TO SAVE THE IMAGE OF AN ENTIRE TABLE (WHICH INVOLVES CONVERTING ALL NUMBERS TO CHARACTER STRINGS, THUS USING A LOT OF CPU TIME AND WORKSPACE). THE ARGUMENTS MAY BE PREPARED USING THE FUNCTION TABLE OR ITS SUBFUNCTIONS LIT (FOR THE MANDATORY PART OF L) AND NUM (WHICH OUTPUTS A VECTOR THAT CAN BE RESHAPED INTO M).

FUNCTION SYNTAX: L TAB M

LEFT ARGUMENT - L:

MUST BE FORMED BY CATENATING CHARACTER VECTORS IN THIS ORDER
1. A MANDATORY VECTOR OF ONE OR MORE CATENATED HEADINGS EACH CONSISTING OF A VECTOR ENDING WITH ∆.
2. A MANDATORY VECTOR OF (⍴M)[1] CATENATED ROW LABLES EACH CONSISTING OF A VECTOR ENDING WITH ∘ .
3. AN OPTIONAL VECTOR WHICH FORMS A CAPTION AT THE FOOT OF THE TABLE AND MAY INCLUDE CARRIAGE RETURNS.

RIGHT ARGUMENT - M:

MUST BE A NUMERICAL MATRIX

FUNCTION OUTPUT:

THERE IS NO RESULTANT. SUCCESSIVE LINES OF THE OUTPUT CONSIST OF
1. HEADINGS, EACH BEING THE CHARACTER STRING PRECEDING A ∆ IN THE LEFT ARGUMENT
2. ROW LABLE, BEING THE CHARACTER STRING PRECEDING THE FIRST ∘ IN THE LEFT ARGUMENT.
3. ROW OF THE NUMERICAL MATRIX
4. FURTHER ALTERATIONS OF 2 AND 3
5. OPTIONALLY, A CAPTION

```
      ∇TAB[⎕]∇
    ∇ L TAB M;Q;R;K
[1]   Q←ρR←(K←0),(L∊'Δ')/ιρL
[2]  HE:L[R[K]+ιR[K+1]-R[K←K+1]+1]
[3]   →(K<Q-1)/HE
[4]   R←(K←0),(L∊'∘')/ιρL←R[Q]↓L
[5]   Q←ρM
[6]   M←((1 0)+Q)ρ(,M),0M[1;]
[7]  PR:L[R[K]+ιR[K+1]-R[K]+1];(1,Q[2])ρM[(K←K+1);]
[8]   →(K<Q[1])/PR
[9]   ρ' '
[10]  R[ρR]↓L
    ∇

      (' ΔONE∘TWO∘THREE∘') TAB (3,4)ρι12

ONE
     1                  2                  3                  4
TWO
     5                  6                  7                  8
THREE
     9                 10                 11                 12


      ('Δ∘∘∘∘') TAB X1-20


     69.11503838        91.10618695        15.70796327

  163.362818          31.41592654        0.83745

     18.84955592          0                18.84955592

    84.82300165         37.69911184       ¯5
```

THERE MAY BE SOME MISALIGNMENTS IF THERE ARE LARGE VARIATIONS IN MAGNITUDE WITHIN THE MATRIX. IF THE VARIATIONS ARE GREAT, THE MATRIX WILL APPEAR IN EXPONENTIAL FORM.

TABLEHOW

TABLE
06/08/70
CONFIDENCE CODE: *C*
1-*ORIGIN INDEXING*
DR.G.H.MCLAUGHLIN
NEWHOUSE COMMUNICATIONS CENTER, SYR. UNIV. *X*2747

FUNCTION DESCRIPTION

TABLE IS A CONVERSATIONAL FUNCTION WHICH HELPS THE USER TO PREPARE A NUMERICAL TABULATION WITH CENTERED HEADINGS, ROW LABELS, AND A CAPTION AS REQUIRED. IT THEN PRINTS OUT THE TABLE USING THE SUBFUNCTION TAB . THE USE OF TABLE IS BEST UNDERSTOOD BY INSPECTING A DISPLAY OF THE FUNCTION.

FUNCTION SYNTAX: *TABLE*

FUNCTION OUTPUT:

THE OUTPUT IS THAT OF TAB . SEE TABHOW.

```
      ∇TABLE[⎕]∇
    ∇ TABLE;V;RR;Q;M;L;LI;T;K;C
[1]   'THIS FUNCTION PRINTS OUT A NUMERICAL MATRIX WITH CENTERED MAIN'
[2]   'AND COLUMN HEADINGS, ROW LABLES AND A CAPTION AS REQUIRED.'
[3]   'ENTER THE MATRIX OR, IF ASSISTANCE IN PREPARING THE MATRIX IS'
[4]   'REQUIRED, TYPE 0'
[5]   →(2=ρρM←⎕)/EM
[6]   'YOU ARE ABOUT TO USE THE FUNCTION NUM TO PREPARE A VECTOR V'
[7]   'WHICH WILL BE RESHAPED AS A MATRIX M. ENTER THE NUMBER OF ROWS'
[8]   'REQUIRED IN M'
[9]   RR←⎕
[10]  'ENTER THE NUMBER OF COLUMNS REQUIRED'
[11]  Q←⎕
[12]  'MAKE SURE YOU ENTER ';RR×Q;' ELEMENTS IN V. LATER, WHEN'
[13]  'NUM[54] OR NUM[59] IS PRINTED OUT, TYPE M←V THEN PRESS THE'
[14]  'RETURN KEY AND TYPE →59'
[15]  SΔNUM←54
[16]  NUM
[17]  M←(RR,Q)ρM
```

```
      ∇TABLE[⎕18]∇
[18] EM:'ENTER EITHER A VECTOR OF ';RR←(ρM)[1];' ROW LABLES EACH'
[19]  'FOLLOWED BY A ∘ SYMBOL OR 0 TO INDICATE THAT ROW LABLES ARE'
[20]  'NOT REQUIRED OR 1 TO OBTAIN HELP'
[21]  →((∧/LL='1'),1<ρLL←,⍞)/NO,HE
[22]  LL←(2×RR)ρ' ∘'
[23]  →HE
[24] NO:'YOU ARE ABOUT TO USE THE FUNCTION LIT. LATER, WHEN LIT[69]'
[25]  'OR LIT[74] IS PRINTED OUT, TYPE LL←V'
[26]  'THEN PRESS THE RETURN KEY AND TYPE →74'
[27]  S∆LIT←69
[28]  LIT
[29] HE:→((ρR←0,(LL∊'∘')/ιρLL)=1+RR)/PR
[30]  'YOU HAVE ENTERED ';¯1+ρR;' LABLES FOR ';RR;' ROWS OF THE MATRI
      X'
[31]  'THE FUNCTION  LIT WILL NOW HELP YOU TO CORRECT LL, THE'
[32]  'VECTOR OF ROW LABELS.'
[33]  →NO
[34] PR:'TYPE ONE LINE OF HEADING, WHICH MUST BE NO LONGER THAN THE'
[35]  'INDICATOR BELOW. IF IT IS SHORTER, THE HEADING WILL BE'
[36]  'CENTERED AUTOMATICALLY IN THE PRINTOUT. A HEADING CAN BE'
[37]  'SUBDIVIDED TO PROVIDE LABELS FOR INDIVIDUAL COLUMNS OR GROUPS'
[38]  'OF COLUMNS (TO ASSIST IN THIS, THE LENGTH INDICATOR MARKS THE'
[39]  'END OF EACH COLUMN WITH ∇).  TO LEAVE THE LINE BLANK, PRESS'
[40]  'THE SPACE BAR ONCE. AFTER MAKING YOUR ENTRY, PRESS THE RETURN'
[41]  'KEY AND TYPE EITHER ι0 TO TERMINATE OR 1 TO ENTER A FURTHER'
[42]  'LINE, OR LI TO HAVE THE LENGTH INDICATOR TYPED OUT AGAIN'
[43]  'BEFORE YOU ENTER A NEW LINE'
[44]  ⎕←LI←((Q←17×(ρM)[2])ρ(16ρ'⊥'),'∇'),K←ρ' '
[45] EN:K←K,((⌈(Q-ρT)÷2)ρ' '),T←⍞,'∆'
[46]  →(0<ρ⎕←,⎕)/EN
[47]  'IF A CAPTION IS REQUIRED AT THE FOOT OF THE TABLE, TYPE 1'
[48]  'OTHERWISE 0'
[49]  →(~⎕)/PR
[50]  'THE CAPTION, WHICH WILL NOT BE CENTERED AUTOMATICALLY, MAY'
[51]  'CONSIST OF AS MANY LINES AS DESIRED. PRESS THE RETURN KEY AT'
[52]  'THE END OF EACH LINE, WHICH MUST BE NO LONGER THAN THIS'
[53]  LI,C←ι0
[54]  'TO TERMINATE TYPE ⊥'
[55] CA:→(('⊥')≠C[ρC←C,'
      ',⍞])/CA
[56]  K←K,LL,¯1↓C
[57]  LL←C←ι0
[58]  'TO SAVE THE CHARACTER STRINGS ENTERED SO FAR, TYPE N←R WHERE'
[59]  'N IS A NAME OF YOUR CHOICE. (ALSO, IF THE NUMERICAL MATRIX'
[60]  'HAS NOT BEEN SAVED PREVIOUSLY, TYPE NM←M, WHERE NM IS ANOTHER'
[61]  'NAME). THEN TYPE )SAVE .  TO TERMINATE TYPE →0 .  TO OBTAIN A'
[62]  'PRINTOUT, TYPE →65 .  BUT DO NOT PRESS THE RETURN KEY UNTIL'
[63]  'YOU HAVE ADJUSTED THE PAPER.'
[64]  S∆TABLE←1+⌶26
[65]  K TAB M
```

```
      TABLE
THIS FUNCTION PRINTS OUT A NUMERICAL MATRIX WITH CENTERED MAIN
AND COLUMN HEADINGS, ROW LABLES AND A CAPTION AS REQUIRED.
ENTER THE MATRIX OR, IF ASSISTANCE IN PREPARING THE MATRIX IS
REQUIRED, TYPE 0
⎕:
      X1
ENTER EITHER A VECTOR OF 4 ROW LABLES EACH
FOLLOWED BY A ∘ SYMBOL OR 0 TO INDICATE THAT ROW LABLES ARE
NOT REQUIRED OR 1 TO OBTAIN HELP
ONE∘TWO∘THREE∘
YOU HAVE ENTERED 3 LABLES FOR 4 ROWS OF THE MATRIX
THE FUNCTION  LIT WILL NOW HELP YOU TO CORRECT LL, THE
VECTOR OF ROW LABELS.
YOU ARE ABOUT TO USE THE FUNCTION LIT. LATER, WHEN LIT[69]
OR LIT[74] IS PRINTED OUT, TYPE LL←V
THEN PRESS THE RETURN KEY AND TYPE →74
TO SKIP DETAILED INSTRUCTIONS, TYPE  1  ; OTHERWISE TYPE  0
⎕:
      1
TO EDIT AN EXISTING ARRAY, TYPE ITS NAME.  OTHERWISE TYPE 0
⎕:
      LL
FOR A NUMBERED LIST OF ENTRIES, TYPE  1  ; OTHERWISE  0
⎕:
      0
WHEN CORRECTIONS ARE ALL DONE, TYPE  7
⎕:
      5
FOUR⊥
EXTRA LINE 1 CHARACTERS: 4   TOTAL: 4
⎕:
      7

LIT[74]
      LL←V
      →74
TYPE ONE LINE OF HEADING, WHICH MUST BE NO LONGER THAN THE
INDICATOR BELOW. IF IT IS SHORTER, THE HEADING WILL BE
CENTERED AUTOMATICALLY IN THE PRINTOUT. A HEADING CAN BE
SUBDIVIDED TO PROVIDE LABELS FOR INDIVIDUAL COLUMNS OR GROUPS
OF COLUMNS (TO ASSIST IN THIS, THE LENGTH INDICATOR MARKS THE
END OF EACH COLUMN WITH ∇).  TO LEAVE THE LINE BLANK, PRESS
THE SPACE BAR ONCE. AFTER MAKING YOUR ENTRY, PRESS THE RETURN
KEY AND TYPE EITHER ⍳0 TO TERMINATE OR 1 TO ENTER A FURTHER
LINE, OR LI TO HAVE THE LENGTH INDICATOR TYPED OUT AGAIN
BEFORE YOU ENTER A NEW LINE
⊥⊥⊥⊥⊥⊥⊥⊥⊥⊥⊥⊥⊥⊥⊥⊥∇⊥⊥⊥⊥⊥⊥⊥⊥⊥⊥⊥⊥⊥⊥⊥⊥∇⊥⊥⊥⊥⊥⊥⊥⊥⊥⊥⊥⊥⊥⊥⊥⊥∇
TABLE I
⎕:
      1
1

⎕:
```

```
      LI
⊥⊥⊥⊥⊥⊥⊥⊥⊥⊥⊥⊥⊥⊥⊥⊥∇⊥⊥⊥⊥⊥⊥⊥⊥⊥⊥⊥⊥⊥⊥⊥⊥∇⊥⊥⊥⊥⊥⊥⊥⊥⊥⊥⊥⊥⊥⊥⊥⊥∇
    COLUMN 1         COLUMN 2         COLUMN 3
⎕:
      ⍳0

IF A CAPTION IS REQUIRED AT THE FOOT OF THE TABLE, TYPE 1
OTHERWISE 0
⎕:
      1
THE CAPTION, WHICH WILL NOT BE CENTERED AUTOMATICALLY, MAY
CONSIST OF AS MANY LINES AS DESIRED. PRESS THE RETURN KEY AT
THE END OF EACH LINE, WHICH MUST BE NO LONGER THAN THIS
⊥⊥⊥⊥⊥⊥⊥⊥⊥⊥⊥⊥⊥⊥⊥⊥∇⊥⊥⊥⊥⊥⊥⊥⊥⊥⊥⊥⊥⊥⊥⊥⊥∇⊥⊥⊥⊥⊥⊥⊥⊥⊥⊥⊥⊥⊥⊥⊥⊥∇
TO TERMINATE TYPE ⊥
  THIS LINE WILL BE PRINTER
                          ∨
                          D OUT AS A CAPTION
  OF TWO LINES SET 2 SPACES FROM THE LEFT.⊥
TO SAVE THE CHARACTER STRINGS ENTERED SO FAR, TYPE N←R WHERE
N IS A NAME OF YOUR CHOICE. (ALSO, IF THE NUMERICAL MATRIX
HAS NOT BEEN SAVED PREVIOUSLY, TYPE NM←M, WHERE NM IS ANOTHER
NAME). THEN TYPE )SAVE .  TO TERMINATE TYPE →0 .  TO OBTAIN A
PRINTOUT, TYPE →65 .  BUT DO NOT PRESS THE RETURN KEY UNTIL
YOU HAVE ADJUSTED THE PAPER.

TABLE[65]
      →65
                      TABLE I

      COLUMN 1         COLUMN 2         COLUMN 3
ONE
     89.11503838     111.106187       35.70796327
TWO
    183.362818        51.41592654     20.83745
THREE
     38.84955592      20              38.84955592
FOUR
    104.8230016       57.69911184     15


  THIS LINE WILL BE PRINTED OUT AS A CAPTION
  OF TWO LINES SET 2 SPACES FROM THE LEFT.
```